

Plant Breeding Abstracts

Chickpea breeding — progress and prospects

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ABSTRACT

Chickpea (*Cicer arietinum*), grown on about 10 million ha annually, is the world's third most important pulse crop. Although its breeding history is short, considerable progress has been made in cultivar improvement. Breeding cultivars with resistance to freezing, *Fusarium oxysporum* f.sp. *ciceris*, *Ascochyta rabiei* and *Helicoverpa armigera*, and for short duration are examples of successes. Yield stability has increased and yield gains of 1.6% per annum have been achieved. In the West Asia and Mediterranean region, drought avoidance by winter sowing has been achieved by incorporating disease resistance and changing the sowing date. This has resulted in a 75% yield increase. A 20% yield increase was recorded in peninsular India because of the extra-short duration.

The prospects for additional gains from breeding are good. Desirable traits include resistance to high temperature, salinity, *Botrytis cinerea*, *Sclerotium*[*Corticium*] *rolfsii*, *Liriomyza cicerina* and stunt caused by bean leaf roll luteovirus. Attention should also be given to the problems of chilling and lodging in the most productive chickpea-growing areas. The possibilities of applying new biotechnological methods for genetic improvement, particularly the use of interspecific crossing, micropropagation, somaclonal variation, and isoenzyme and restriction fragment length polymorphism (RFLP) mapping, are discussed.

INTRODUCTION

Chickpea, after dry bean and dry pea, is the third most important pulse crop in the world. It is grown annually on about 10 million ha, and produces on average 650 kg/ha. It is an ancient crop; its oldest remains, found at Hacilar in Turkey, date back to 5450 BC. No other pulse is used in as many ways as chickpea. The leaves may be eaten as a vegetable, a refreshing drink can be prepared from the plant exudates, the green seeds may be consumed raw, roasted or boiled, and the dried seeds can be used to prepare an amazing array of different dishes. Most of the seed is used for human consumption, but some is fed to animals (to pigs, for instance, in Mexico). Animals also like chickpea hay. No other crop is covered on all its surfaces with an acid exudate and few have, possibly as a consequence, so few insect problems.

Two types are usually distinguished within the species *C. arietinum*: the small- and brown-seeded desi, and the large- and white-seeded kabuli, the garbanzo blanco bean of international commerce, and a favourite component of salads.

Chickpeas, mainly desi, are widely cultivated in the Indian subcontinent. However, West Asia is also an important producer, of kabuli mainly, and Turkey is the top producer in the region. The Mediterranean countries of Asia, North Africa and Europe have been famous for their kabuli chickpea from ancient times, but in Europe the production has dwindled over the past 25 years. Attempts, however, are now being made to revive it. In some parts of the world, chickpea production has shown rapid and unexpected increases within the past 10 years. For instance, the area under chickpea in Australia has increased from 6000 ha in 1985 to an estimated 150 000 ha in 1990. The largest producer of chickpea in Africa is Ethiopia, where there are approximately 180 000 ha of the

crop, mainly desi. In the Americas, Mexico is the top producer and grows an estimated 140 000 ha of chickpea annually, with equal amounts of desi and kabuli.

The fact that mean world chickpea yields over the years 1961-63, 1976-78 and 1986-88 were a rather steady 613, 682 and 700 kg/ha leads one to question what progress research on chickpea, breeding included, has made. Before answering, it must be realized that the history of chickpea breeding is relatively short (Singh, 1987).

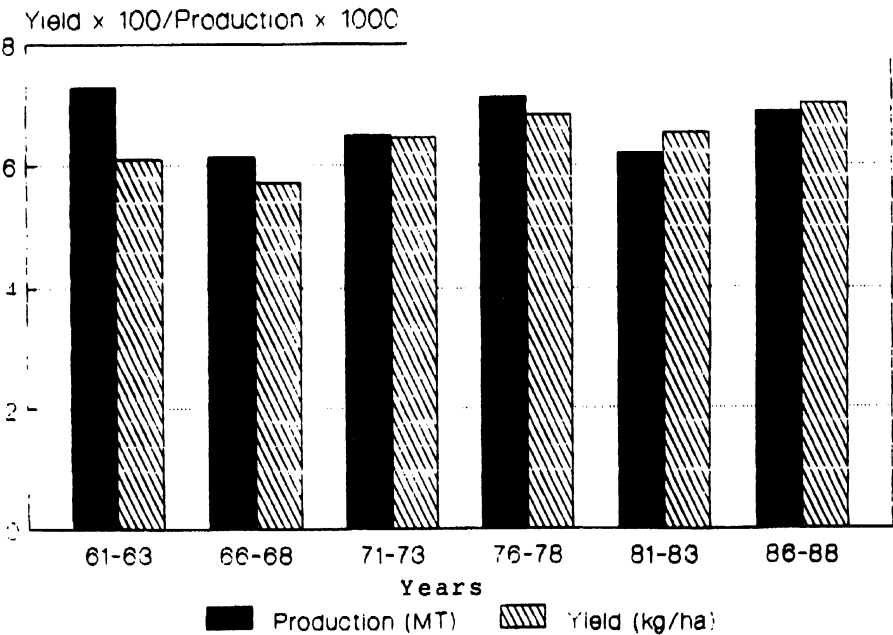
Early in the 20th century, a modest beginning was made to breed chickpea in India, but only from 1966, when the All India Coordinated Pulses Improvement Project (AICPIP) was initiated, has there been a concerted national effort to improve chickpea. Morocco, Tunisia, Spain, Greece, Turkey and Italy began chickpea improvement before the forties, but the scope of their programmes remained small. In Mexico, the history of chickpea breeding goes back to 1958; it was the first country to develop a wilt-sick plot to screen chickpea for resistance to fusarium wilt. Ethiopia initiated its chickpea breeding in 1967. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) at Patancheru, India, became involved in chickpea research in 1972 and the International Centre for Agricultural Research in Dry Areas (ICARDA) at Tel Hadya, Syria in 1977. Recent work reported from Canada and the USA involves analysis of isoenzyme and RFLP for chickpea breeding, and the development of high density gene maps has begun.

Much of the chickpea breeding research literature is in Indian journals, but significant reports have appeared in other international journals. The International Chickpea Newsletter, issued from ICRISAT since 1979, informs readers twice a year about the latest developments in chickpea improvement. CAB International (formerly the Commonwealth Agricultural Bureaux), in association with ICRISAT, began publishing in March 1988 the quarterly CAB prompts series for chickpea and pigeonpea as a current awareness publication for timely dissemination of research findings.

PROGRESS IN CHICKPEA BREEDING

Smithson *et al.* (1985) described the breeding advances made in chickpea research at ICRISAT and suggested that the main reason for the stagnation in chickpea production (Fig. 1) was its yield instability. Since then, the constraints leading to yield instability have been further analysed and ranked to obtain a global picture of major problems and their distribution (Table 1)). Breeding efforts have been directed towards the alleviation of these constraints, both abiotic and biotic, to help achieve the main objectives of stable high yield and quality. This work is discussed in the following sections.

Three years' world means of chickpea production and yield during 1961-1988



Source: FAO Production Yearbook 1962-89

Fig. 1. World production and yield of chickpea from 1961-63 to 1986-88.

Table 1. Ranking of desirable characters for chickpea in different zones of the world.

Desirable characteristics	Zones (degrees latitude)				
	A 0–20	B 20–25	C 25–30	D 30–45	
Stable, high yield	+	+	+	+	
Good seed quality	+	+	+	+	
Resistance to stresses					
Biotic					
<i>Fusarium</i> wilt	2–1	2–1	2–1	3	
<i>Ascochyta</i> blight	–	–	6*	1	
<i>Botrytis</i> grey mold	–	5	3	–	
Root rots	3	3	5	4	
Stunt	4	4	4	5	
<i>Helicoverpa</i>	1–2	1–2	1–2	6	
Leaf miner	–	–	–	2	
Nematodes	?	?	7?	7?	
Abiotic					
				Spring	Winter
Drought	1	1	1	1	–
Salinity	3	3	2	–	–
Excessive moisture	–	4	5	–	2
High temperature	2	2	4	2	–
Low temperature	–	–	3	–	1

* in case of epidemics, the crop damage is severe.

+ required.

– not required.

? uncertain.

Source: van Rheenen (1991)

First, the abiotic constraints. van Rheenen *et al.* (1990) distinguished between abiotic stresses, where cultural practices have little effect, such as temperature extremes, and those where cultural practices can be effective in alleviating the stress, for instance drought, and they discussed these accordingly. In this review, the ranking shown in Table 1 is followed, and a more holistic approach adopted.

1. Drought

Chickpea is commonly grown on residual moisture, and this practice is probably the main reason for the world's low and variable yield (Fig 1). The mean yield and its CV from 1961–88 were 642 kg/ha and 11%. For rainfed chickpea, the following options seem to be open to alleviate drought stress:

1. sowing during the rainy season,
2. growing short-duration cultivars,
3. using drought-resistant cultivars.

These options will be discussed in detail, since they are concerned with the foremost problem: drought.

(a) Chickpea as a rainy season crop

In West Asia and the Mediterranean region (zone D in Table 1), chickpea is usually sown in the spring and grows on residual moisture from winter rains. In regions of zones A, B and C, chickpea is commonly sown in the autumn on residual moisture from the summer rains. To grow a rainy-season crop, zone D needs to change from spring to autumn sowing, and zones A and B from autumn to summer sowing. Transition zone C is the highest in production, and requires no change. The 2 situations have similarities, but also differ considerably as will become apparent.

(b) From spring to autumn sowing

(zone D in Table 1)

The idea of sowing chickpea in the autumn to use the scarce winter rains must have occurred to farmers in zone D as it did to ICARDA's scientists. However, a disease of little significance for a spring-sown crop posed a serious threat to an autumn-sown crop. The disease is ascochyta blight, caused by the fungus *Ascochyta rabiei*.

In a search for resistance to this disease, more than 13 000 germplasm accessions were screened at ICARDA and 17 genotypes identified as resistant. These have been used in breeding programmes and the resulting cultivars have helped to stabilize production and increase yield by about 75%, a spectacular success indeed (Nene and Reddy, 1987). Apart from ascochyta blight, winter cold also endangered the autumn-sown crop. An extensive screening, breeding and research programme resulted in the development of freezing resistant lines (Singh, *et al.*, 1989). One need only see the dramatic differences in resistance to ascochyta blight and to frost damage to appreciate this breeding achievement (Fig. 2).

(c) From autumn to summer sowing

(zones A and B in Table 1)

The idea of sowing chickpea in summer to use the summer rains must also have occurred to farmers in zones A and B. Here again, a disease of little significance for an autumn-sown crop threatened the summer-sown chickpea. The disease is colletotrichum blight, caused by *Colletotrichum dematium*.

Apart from colletotrichum blight, waterlogging and high temperatures may also exert adverse effects on summer-sown chickpea. Research at ICRISAT has shown that rain as such does not harm the vegetative growth of a well-drained chickpea crop; that genotypic differences for resistance to colletotrichum blight exist; and that advancing the sowing date by 1 month can increase the yield by 25%. Under low-fertility conditions and without insect control, a yield of 1.5 t/ha was recorded when the sowing date was advanced by 1.5 months in 1989 (Singh *et al.*, 1990b; van Rheenen, 1991).

(d) Short-duration chickpea

The maturation period for chickpea, growing on residual moisture, is closely related to the number of days from sowing to flowering. The earliest-flowering chickpea cultivar in the International Chickpea Germplasm Collection of approximately 16 000 accessions maintained at ICRISAT is ICCV2, a kabuli cultivar (Fig. 3). It was released in 1989 in the state of Andhra Pradesh, India, as Swetha, and has proved popular elsewhere, e.g. in Myanmar. Swetha was selected from a cross involving 5 parents, and combines the desirable traits of extra-short duration, resistance to fusarium wilt and relatively large seed size, the most important being the extra-short duration as it enables the plants to escape drought. In non-irrigated on-farm trials in the state of Maharashtra, India, Swetha flowered about 2 weeks earlier than the control varieties, outyielded these by 20% in 1988/89 and gave a mean yield of 860 kg/ha (Fig. 3). This cultivar represents a significant contribution to the crop's stability through its flexibility in sowing date, its potential for crop rotation, and its short duration of 75 days in which time it can produce 1 t of seed per ha. Subsequent efforts to develop desi varieties of similar duration have produced the varieties ICCV88201 and ICCV88202, and work in this direction has been further intensified.

(e) Drought-resistant chickpea

Screening of germplasm accessions under irrigated and non-irrigated conditions enabled Saxena (1987) to identify 2 drought-resistant lines, ICC4958 and ICC10448. An interesting observation was that ICC4958 exceeded the well-established cultivar of peninsular India, Annigeri, by 30% in root volume and yielded 360 kg/ha (72%) more than Annigeri's yield of 500 kg/ha. At 1700 kg/ha the varieties were at par in yield, and beyond this Annigeri began to exceed ICC4958 in productivity. A diversified bulk population breeding method is being followed for cross populations, with ICC4958 as one of the parents, to widen the adaptation of drought-resistant selections.

2. Temperature constraints

Three different temperature regimes are harmful to chickpea. The temperature can be too low (0°C) and freeze the crop; it can be over 0°C, but still so low (0-5°C) that it causes chilling of the plant and, consequently, flower drop and pod abortion (Buddenhagen and Richards, 1988). Finally, it can become too warm (>30°C) for optimal growth and development. I will discuss these 3 cases separately.

(a) Freezing temperatures

Chickpea sown in the autumn in West Asia and the Mediterranean region may encounter severe winter cold. Monthly minimum temperatures at Tel Hadya, Syria, for instance, may be as low as

about -10°C . Under such conditions, Singh *et al.* (1989) identified 73 germplasm lines from a collection of 2526 that were tolerant of such temperatures. Percentage-wise, Morocco, India and Chile had more resistance in their collections than other contributing countries such as Afghanistan, Algeria, Turkey and the USSR. Inheritance studies revealed that resistance to freezing was dominant, and that it was controlled by at least 5 genes with both additive and non-additive effects and high heritability estimates (Singh *et al.*, 1989). In the breeding programme at Tel Hadya, segregating populations and progenies are sown in advance of the recommended date, and plants or lines that suffer cold injury are rejected. This procedure has resulted in the selection and release of several low-temperature resistant cultivars (Fig. 2).

(b) Chilling temperatures

Chickpea in zone C (Table 1) is usually autumn-sown, and temperatures below 0°C are rare. However, minimum temperatures do reach from 0 to 5°C and can cause flower abortion. Chickpea breeders and physiologists searched for germplasm lines that could retain flowers and set pods under these conditions. Eventually, in 1980/81 at the ICRISAT Cooperative Research Station at Hissar, in northern India, a few plants were observed in F_3 segregating populations that showed pod formation at low temperature. Breeding, using this material, has progressed well and the lines produced hold promise not only for chilling resistance but also for earliness, and therefore have the potential to escape foliar disease and pod-borer (*H. armigera*) attack. In addition, the plants show less profuse vegetative growth than normal types and are less liable to lodge under good growing conditions (Saxena *et al.*, 1988; ICRISAT, 1989 and 1990). This may lead to a breakthrough in chickpea production in a zone where the crop seems to be very well adapted.

(c) High temperatures

It is generally agreed that temperatures above 30°C are harmful to the crop, especially during the reproductive stage. However, the literature contains little of practical relevance in this area and information on screening for heat resistance is almost non-existent. At ICRISAT, some screening for heat resistance is being done by sowing chickpea in January to expose plants to high temperatures (range daily maximum temperature $33-39^{\circ}\text{C}$) in the March-April period. In 1990, one trial entry gave a yield as high as 1.7 t/ha in such a screening test. This type of work deserves more attention, as chickpea is a cool-season crop, but often has to cope with above optimal temperatures.

3. Other abiotic constraints

Chickpea is very sensitive to salinity, and although genotypic differences have been observed, the levels of resistance have been low. Some screening work is being conducted at a few places but only on a small scale. Other soil factors, such as low pH and iron deficiency can affect crop growth. For the latter, chickpea varieties have shown marked differences in susceptibility, and during the course of breeding programmes lines showing severe iron chlorosis symptoms are discarded.

Regarding biotic constraints, 47 diseases and 54 insect pests have been reported from chickpea (Singh *et al.*, 1990a). Fortunately, only 6 diseases are of major importance, and 2 insect pests are of serious concern. I will discuss in more detail those for which progress has been made in breeding.

4. Chickpea diseases

(a) Fusarium wilt

Fusarium wilt, caused by *F. oxysporum* f.sp. *ciceris*, is probably the most widespread disease of chickpea. Wilting of chickpea can be caused by many organisms, and chickpea wilt was earlier referred to as the wilt complex. The unravelling of this complex to its component parts, of which *F. oxysporum* is of major importance (Nene *et al.*, 1978), is a significant success story. Inheritance studies of resistance to this pathogen (Singh *et al.*, 1987) have contributed considerably to current success in breeding resistant varieties. Resistance to race 1 is controlled by 2 recessive and 1 partially dominant gene, which in any combination of 2 confer resistance. Many varieties now being released are resistant to fusarium wilt.

(b) Ascochyta blight

The blight caused by *A. rabiei* can be devastating in certain regions, but may be of little or no significance in others. For example, autumn-sown chickpea in northern Pakistan, north-western India, West Asia, northern Africa and southern Europe can be severely damaged by the disease, but in Mexico, Ethiopia and South Asia it poses no problems. Extensive screening and breeding for

ascochyta blight resistance has helped to alleviate the disease stress in West Asia, the Mediterranean region, Pakistan and northern India (Reddy *et al.*, 1990; Singh *et al.*, 1990a; Malik *et al.*, 1988). Studies of the inheritance of ascochyta-blight resistance report dominant and recessive single gene control (Singh and Reddy, 1989) but genetic control of resistance is probably much more complex than suggested in current literature (Gowen *et al.*, 1989; Malik, B.A., 1990: personal communication).

(c) Other diseases

There are several other fungal diseases such as botrytis grey mould, caused by *B. cinerea*; dry root rot (*Rhizoctonia bataticola*[*Macrophomina phaseolina*] and collar rot (*Sclerotium*[*Corticium*] *rolfsii*) that can seriously damage chickpea in some locations in some seasons. Resistance breeding has been initiated and results are forthcoming, but the work is still in its infancy. The same applies to nematode and viral diseases (Greco and Sharma, 1990; Kaiser *et al.*, 1990). For instance, screening and breeding for resistance to chickpea stunt has resulted in the development of resistant lines (Nene, 1988), but more needs to be known of the causal agent(s) and their mode of transmission (D.V.R. Reddy, 1990: personal communication).

5. Insect pests

There are 2 major chickpea pests, the pod borer *H. armigera* and the leaf miner *L. cicerina*. The former has a world-wide distribution while the latter is restricted to areas in zone D (Table 1).

(a) *Helicoverpa* pod borer

This pest attacks chickpea from the seedling stage to near maturity and can cause severe damage. At ICRISAT, insecticide sprays gave mean values over 8 years of 12% less pod damage and 21% more yield in large chickpea plots. The story of the search for host-plant resistance against the pod borer is fascinating. ICRISAT's entomologists screened more than 14 800 germplasm accessions from 1984-90 in unsprayed areas. The first success came when young plants were noticed which retained part of their foliage when others were completely stripped of leaves by *Helicoverpa*. The best such accession was ICC506. Over 6 years, ICC506 showed a mean of 8.6% pod borer damage and yielded an average of 1.2 t/ha. Over the same period, the popular cultivar Annigeri suffered 29.9% damage and gave a yield of 1.0 t/ha (Reed *et al.*, 1987; Lateef and Pimbert, 1990). The national chickpea research programme in India identified many resistant lines, and recommended some for use as parents in crossing programmes (Sachan, 1990). One problem now overcome was the linkage between pod-borer resistance and susceptibility to fusarium wilt. The line ICCL86102 combines the 2 resistances. Although biochemical factors are being studied for their contribution to insect resistance, results so far have not found practical application in breeding programmes (Rembold *et al.*, 1990).

(b) *Liriomyza* leaf miner

In West Asia, northern Africa and southern Europe, *L. cicerina* is the most important insect pest of chickpea. Resistance screening at ICARDA of 6800 chickpea lines yielded 10 with consistently low leaf miner damage scores (Weigand and Tehhan, 1990). However, within the breeding programmes, resistance screening has still to be established as a routine practice.

(c) Other insects

Other insect pests harmful to chickpea include aphids and white grubs, but no breeding efforts have been undertaken so far to control these. As for storage pests, *Callosobruchus* spp. are the most harmful. Screening 6697 kabuli chickpea lines failed to detect useful resistance to this pest, but the wild species *Cicer echinospermum* was found to be free from seed infestation (Weigand and Tahhan, 1990). A fortunate recent development is the successful crossing of *C. arietinum* × *C. echinospermum* (ICARDA, 1990).

6. Stable yield and high quality

Chickpea breeding for yield and quality has utilized the various methods usually applied to self-pollinated crops. In addition to pure line and mass selection, breeders have used pedigree, bulk population and backcross breeding methods and combinations of these. Population improvement by recurrent selection is exceptional, but mutation breeding for yield has had an impact (Kharkwal, 1989). Smithson (1985) mentioned that because of the ineffectiveness of visual selection for yield, and the magnitude of the genotype × environment interaction, ICRISAT changed from pedigree to bulk methods of breeding from 1978. The approach of multilocal early generation bulk yield testing was adopted and applied to F₂ and F₃ populations. Some other breeding programmes have

followed the same method (Dahiya *et al.*, 1984). However, Geletu (1987) from his study of F_2 - F_6 generations of 9 crosses, concluded that the yield correlations between generations was low, not justifying continuation of the elaborate method of multilocal F_2 / F_3 yield testing. van Rheenen *et al.* (1991) proposed a method called polygon breeding, whereby segregating populations and selections are shared and exchanged between breeders.

Saxena and Johansen (1990) believe that despite intensive breeding efforts, there has been no significant enhancement of yield potential of chickpea over the last 2 decades, and they recommend an ideotype approach for yield improvement. Others have estimated yield increases of 1.6% annually from breeding efforts (ICRISAT, 1990, unpublished report). Let us focus on one recent case of yield improvement for a variety listed by ICRISAT as ICCV10 and yield tested multilocally in 2 zones of peninsular India for 4 years: 1986/87 to 1989/90 (Fig. 4). This variety ranked first each year in both the Central and South zone trials; its mean yield increase over the control varieties in the 2 zones being estimated at 21% in the Central zone and 16% in the South zone trials; average yields were 2.0 t/ha in the Central zone and 1.8 t/ha in the South zone. The variety was developed from a cross between P2559 and the line F_5 (BN10 \times NP34) in 1976, and the annual yield increase may therefore be estimated at 1.3%. This is only one example, but similar progress can be quoted from the national breeding programmes of India and other countries. Several avenues have been followed to achieve yield increase, such as breeding tall or mid-tall types, desi \times kabuli introgression, and employment of the double-podded and multiseeded characters, but such work may have to be pursued to bring forth the expected results (Bahl *et al.*, 1990).

On quality I may be brief. Much research has been conducted and continues on the quality aspects of chickpea (ICRISAT, 1991), but for practical breeding purposes it is mainly the seed appearance that is taken into account during the breeding process, while such quality factors as cooking time and protein content are tested on the elite material.

7. Synthesis and summary

Major yield increases have been reported, resulting from agronomic practices such as irrigation and weed control, and from the use of pesticides, discussion of which is beyond the scope of this mini-review.

Chickpea breeding has been largely defensive in that it has aimed at incorporating factors that alleviate stresses. This has been and still is important as yield stability is the top requirement. Many cultivars have been bred over the years, and the number is increasing rapidly. Singh (1987) has listed 159 cultivars, released from 1926 to 1984 from a range of countries. Several already have specific stability factors. A major increase in yield of about 75% has been reported from West Asian and Mediterranean countries by breeding for a combination of ascochyta blight and freezing resistance, and by changing the date of sowing from spring to autumn. The trend towards shorter-duration chickpea in peninsular India has been beneficial in that yield increases of about 20% have been achieved. There has been a steady yield improvement, exemplified by the variety ICCV10, with estimated 1.3% increase per annum. Several interesting and promising new approaches to chickpea improvement are being followed. I will discuss these in the section on prospects although some have been mentioned already.

PROSPECTS FOR CHICKPEA BREEDING

As we have seen, chickpea is subject to many stress factors, both abiotic and biotic; most of these have not been studied in depth, and many have received hardly any attention, for example, high temperature effects, salinity, collar rot and nematodes. It must be remembered that chickpea's breeding history spans only a short period and therefore the prospects seem promising. Breeding for resistance to adverse factors is likely to be a rewarding task. Germplasm enhancement will need to receive more emphasis in this context. The use of chilling resistance for a major chickpea-production belt is to be further probed, promoted and consolidated. For the same areas, lodging resistance may contribute much to maximizing yield. The breeding of extra-short duration chickpea has just started to bear fruit with the release of cv. ICCV2 in 1989. It is anticipated that advances in this area will be rapid. Taking the crop out of the critical period of residual moisture by changing sowing date has been successful in West Asia, North Africa and southern Europe. This approach may also succeed in regions of lower latitude, thus opening areas more promising for yield and resistance breeding than the marginal areas used at the present time. Mutation breeding as a tool to improve varieties for specific characteristics may contribute even more than it has done so far. The expected benefits from the application of biotechnology to chickpea have been described by van Rheenen *et al.* (1988). The main practical interests for the breeder are probably, at the moment, interspecific crossing, somaclonal variation and micropropagation, although transfer of desirable genes by recombinant DNA techniques is his dream. The recently initiated work based on isoenzyme and restriction fragment length polymorphisms is important, especially for the construction of saturated gene maps

that show linkages with agronomically important characters that are hard to select for (Muehlbauer *et al.*, 1990). I conclude that the pathways leading to progress are many.

I return now briefly to the question asked in the introduction in connection with the steady yields over several years. Chickpea lacks the long breeding history and scientific input that some other crops, particularly cereals, have received. Competition with the latter has pushed chickpea onto the poorer land. However, signs of change are evident from the recent progress described, and given a little more time the prospects for this pulse crop, which is gaining popularity worldwide, seem hopeful and encouraging.

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REFERENCES

- Bahl, P. N.; Salimath, P. M.; Malik, B. A.; Dahiya, B. S.; Deshmukh, R. B.; Rangasamy, P. (1990) New approaches in chickpea breeding and prospects in the nineties. In: *Chickpea in the Nineties. Proceedings of the Second International Workshop on Chickpea Improvement, 4-8 December 1989, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 225-231.
- Buddenhagen, I. W.; Richards, R. A. (1988) Breeding cool season food legumes for improved performance in stress environments. In: *World Crops: cool season food legumes. Proceedings of the International Food Legume Research Conference on Pea, Lentil, Faba Bean and Chickpea, 6-11 July 1986, Spokane, Washington, USA*. Dordrecht, Netherlands; Kluwer Academic Publishers. pp. 81-96.
- Dahiya, B. S.; Waldia, R. S.; Kaushik, L. S.; Solanki, I. S. (1984) Early generation yield testing versus visual selection in chickpea (*Cicer arietinum* L.). *Theoretical and Applied Genetics* **68**, 525-529.
- Geletu, B. (1987) Relationships among the F₂ to F₆ generations, and effect of spacing and selection in F₄ on performance in F₅ generation in chickpea. *Ph.D. Thesis, submitted to the Andhra Pradesh Agricultural University, Hyderabad, India*. 149 pp.
- Gowen, S. R.; Orton, M.; Thurley, B.; White, A. (1989) Variation in pathogenicity of *Ascochyta rabiei* on chickpeas. *Tropical Pest Management* **35** (2) 180-186.
- Greco, N.; Sharma, S. B. (1990) Progress and problems in the management of nematode diseases. In: *Chickpea in the Nineties. Proceedings of the Second International Workshop on Chickpea Improvement, 4-8 December 1989, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 135-137.
- ICARDA (International Center for Agricultural Research in the Dry Areas) (1990) *Annual Report for 1989, Food Legume Improvement Programme*. Aleppo, Syria; ICARDA. pp. 54-59.
- ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) (1989) *Annual Report 1988*. Patancheru, India; ICRISAT. pp. 60-61.
- ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) (1990) *Annual Report 1989*. Patancheru, India; ICRISAT. pp. 86-87.
- ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) (1991) *Proceedings of the Consultancy meeting on uses of grain legumes, 27-28 March 1989, ICRISAT Center, India*. Patancheru, India; ICRISAT (in press)
- Kaiser, W. J.; Ghanekar, A. M.; Nene, Y. L.; Rao, B. S.; Anjaiah, V. (1990) Viral diseases of chickpea. In: *Chickpea in the Nineties. Proceedings of the Second International Workshop on Chickpea Improvement, 4-8 December 1989, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 139-142.
- Kharkwal, M. C. (1989) Mutant varieties of gram for rainfed areas. In: *Maximising crop production in rainfed and problem areas. Proceedings of the National Seminar on 'Integrated management approach for maximizing crop production in rainfed and problem areas', 26-28 February 1986, IARI, New Delhi, India*.
- Lateef, S. S.; Pimbert, M. P. (1990) The search for host-plant resistance to *Helicoverpa armigera* in chickpea and pigeonpea at ICRISAT. In: *Summary proceedings of the first consultative group meeting on the host selection behaviour of Helicoverpa armigera, 5-7 March 1990, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 14-18.
- Malik, B. A.; Verma, M. M.; Rahman, M. M.; Bhattarai, A. N. (1988) Production of chickpea, lentil, pea and faba bean in South-East Asia. In: *World Crops: cool season food legumes. Proceedings of the International Food Legume Research Conference on Pea, Lentil, Faba bean and Chickpea, 6-11 July 1986, Spokane, Washington, USA*. Dordrecht, Netherlands; Kluwer Academic Publishers. pp. 1095-1111.
- Muehlbauer, F. J.; Simon, C. J.; Spaeth, S. C.; Haddad, N. I. (1990) Genetic improvement of chickpea: key factors to be considered for a breakthrough in productivity. In: *Chickpea in the Nineties. Proceedings of the Second International Workshop on Chickpea Improvement, 4-8 December 1989, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 209-216.
- Nene, Y. L.; Haware, M. P.; Reddy, M. V. (1978) Diagnosis of some wilt-like disorders of chickpea (*Cicer arietinum* L.). *Information Bulletin* **3**, ICRISAT, Patancheru, India. 44 pp.
- Nene, Y. L.; Reddy, M. V. (1987) Chickpea diseases and their control. In: *The Chickpea*. Wallingford, UK; CAB International. pp. 233-270.
- Nene, Y. L. (1988) Multiple-disease resistance in grain legumes. *Annual Review of Phytopathology* **26**, 203-127.

- Reddy, M. V.; Nene, Y. L.; Gurdip Singh; Bashir, M. (1990) Strategies for management of foliar diseases of chickpea. In: *Chickpea in the Nineties. Proceedings of the Second International Workshop on Chickpea Improvement, 4-8 December 1989, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 117-127.
- Reed, W.; Cardona, C.; Sithanatham, S.; Lateef, S. S. (1987) Chickpea insect pests and their control. In: *The Chickpea*. Wallingford, UK.; CAB International. pp. 283-318.
- Rembold, H.; Schroth, A.; Lateef, S. S.; Weigner, C. (1990) Semiochemicals and host-plant selection by *Helicoverpa armigera*: basic studies in the laboratory for the field. In: *Summary proceedings of the first consultative group meeting on the host selection behaviour of Helicoverpa armigera, 5-7 March 1990, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 14-18.
- Sachan, J. N. (1990) Progress in host-plant resistance work in chickpea and pigeonpea against *Helicoverpa armigera* (Hubner) in India. In: *Summary proceedings of the first consultative group meeting on the host selection behaviour of Helicoverpa armigera, 5-7 March 1990, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 14-18.
- Saxena, N. P. (1987) Screening for adaptation to drought: case studies with chickpea and pigeonpea. In: *Adaptation of chickpea and pigeonpea to abiotic stresses: proceedings of the consultants' workshop, 19-21 December 1984, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 63-76.
- Saxena, N. P.; Johansen, C.; Sethi, S. C.; Talwar, H. S.; Krishnamurthy, L. (1988) Improving harvest index in chickpea through incorporation of cold tolerance. *International Chickpea Newsletter* 19, 17-19.
- Saxena, N. P.; Johansen, C. (1990) Chickpea ideotypes for genetic enhancement of yield and yield stability in South Asia. In: *Chickpea in the Nineties. Proceedings of the Second International Workshop on Chickpea Improvement, 4-8 December 1989, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 81-85.
- Singh, H.; Kumar, J.; Smithson, J. B.; Haware, M. P. (1987) Complementation between genes for resistance to race 1 of *Fusarium oxysporum* f.sp. *ciceri* in chickpea. *Plant Pathology* 36, 539-543. Singh, K. B. (1987) Chickpea breeding. In: *The Chickpea*. Wallingford, UK.; CAB International. pp. 127-162.
- Singh, K. B.; Malhotra, R. S.; Saxena, M. C. (1989) Chickpea evaluation for cold tolerance under field conditions. *Crop Science* 29, 282-285.
- Singh, K. B.; Reddy, M. V. (1989) Genetics of resistance to ascochyta blight in four chickpea lines. *Crop Science* 29, 657-659.
- Singh, K. B.; Kumar, J.; Harware, M. P.; Lateef, S. S. (1990a) Disease and pest resistance breeding: which way to go in the nineties? In: *Chickpea in the Nineties. Proceedings of the Second International Workshop on Chickpea Improvement, 4-8 December 1989, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 233-238.
- Singh, K. B.; Saxena, N. P.; Singh, O.; Saccardo, F.; Acikgoz, N.; Knights, E. J. (1990b) Breeding chickpea for new applications. In: *Chickpea in the Nineties. Proceedings of the Second International Workshop on Chickpea Improvement, 4-8 December 1989, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 245-250.
- Smithson, J. B. (1985) Breeding advances in chickpeas at ICRISAT. In: *Progress in Plant Breeding*. London, UK; Butterworths. pp. 223-237.
- Smithson, J. B.; Thompson, J. A.; Summerfield, R. J. (1985) Chickpea (*Cicer arietinum* L.). In: *Grain legume crops*. London, UK; Collins. pp. 312-390.
- van Rheenen, H. A.; Bond, D. A.; Erskine, W.; Sharma, B. (1988) Future breeding strategies for pea, lentil, faba bean and chickpea. In: *World crops: cool season food legumes. Proceedings of the International Food Legume Research Conference of Pea, Lentil, Faba bean and Chickpea, 6-11 July 1986, Spokane, Washington, USA*. Dordrecht, Netherlands; Kluwer Academic Publishers. pp. 1013-1029.
- van Rheenan, H. A.; Saxena, N. P.; Singh, K. B.; Sethi, S. C.; Acosta-Gallegos, J. A. (1990) Breeding chickpea for resistance to abiotic stresses: what are the problems and how can we solve them? In: *Chickpea in the Nineties. Proceedings of the Second International Workshop on Chickpea Improvement, 4-8 December 1989, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 239-243.
- van Rheenen, H. A. (1991) Production aspects and prospects of chickpea. In: *Proceedings of the consultancy meeting on uses of grain legumes, 27-28 March 1989, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. (in press)
- van Rheenen, H. A.; Rangasamy, P.; Shinde, V. K. (1991) Polygon breeding: old hat or new trick. *International Chickpea Newsletter*. (in press)
- Weigand, S.; Tahhan, O. (1990) Chickpea insect pests in the Mediterranean zones and new approaches to their management. In: *Chickpea in the Nineties. Proceedings of the Second International Workshop on Chickpea Improvement, 4-8 December 1989, ICRISAT Center, India*. Patancheru, India; International Crops Research Institute for the Semi-Arid Tropics. pp. 169-175.

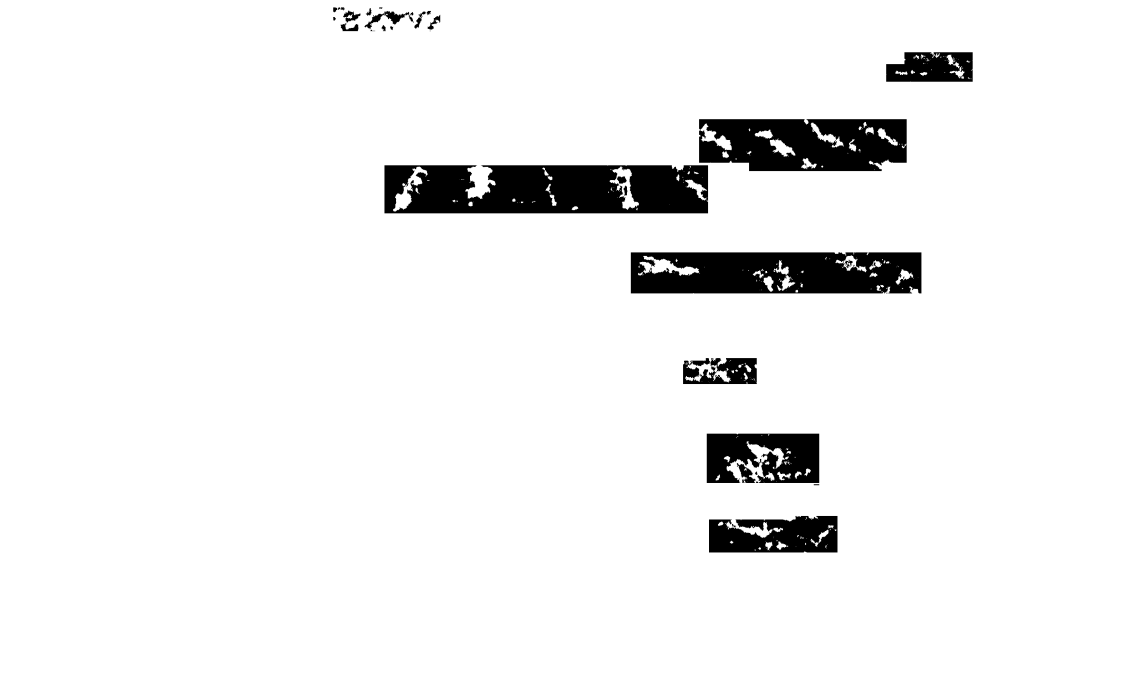


Fig. 2 Resistance (right) and susceptibility (left) to frost damage at ICARDA, Tel Hadya, Syria, 1989



Fig. 3. Chickpea variety ICCV2 growing in a farmer's field in Maharashtra, India. Inset: seed

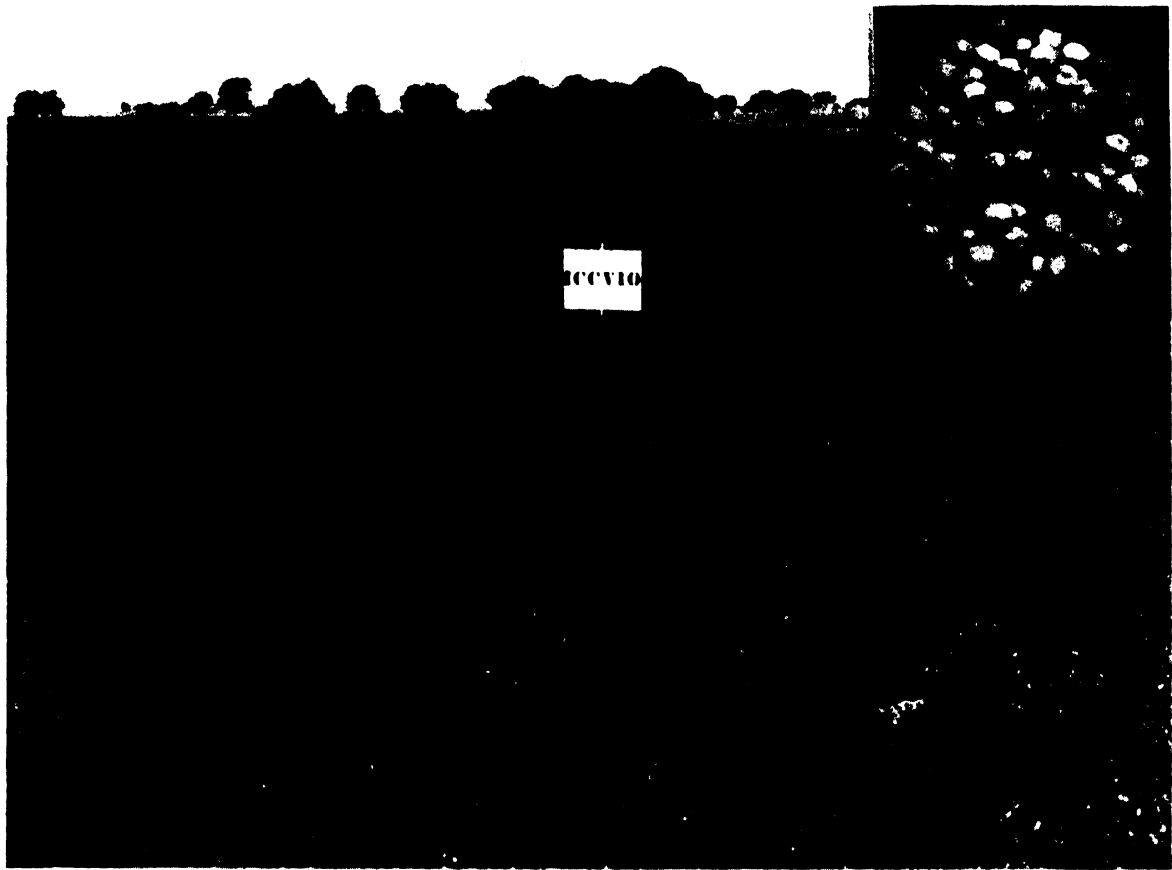


Fig. 4. Chickpea variety ICCV10. Inset: seed.

- Lupinus luteus** *cont.*
varieties
Akademicheskii 8214
Kastychnik 8214
- Lycium barbarum**
endosperm 8393
polyploidy 8393
tissue culture 8393
- Lycopersicon**
salinity 8656
Septoria lycopersici 8659
- Lycopersicon esculentum**
anatomy 8649
breeding 7835, 8636
computer simulation
linkage 8644
recombination 8644
cucumber mosaic cucumovirus 8661
ethyl methanesulfonate 8647
fruits 8649
genetic transformation, β -fructofuranosidase 8645
genetic variance
Phytophthora nicotianae 8660
salinity 8657
genetics
Helicoverpa armigera 8663
Leptinotarsa decemlineata 8663
Phytophthora nicotianae 8660
germplasm releases 8637
grafting 8651
growth period 8636, 8653
habit 8648
hybrid varieties 8641
induced mutations, alcohol
dehydrogenase 8647
interspecific hybridization 8643
Meloidogyne 8662
mitochondrial genetics 8643
molecular genetics, alcohol
dehydrogenase 8647
mutagens 8647
mutations
colour 8650
flowers 8651
gibberellins 8646
inflorescences 8650
roots 8646
pleiotropy
colour 8650
inflorescences 8650
potato X potexvirus 8661
protoplast fusion 8643
quality 8655
seeds 8649
Septoria lycopersici 8659
techniques
germination 8652
stress 7845
tobacco mosaic tobamovirus 8661
Xanthomonas campestris 8658
varieties
Bakhtimir 8579, 8642
Boyan 8636
Curato 8661
Kristi 8661
Liya 8579
Mountain Delight 8637
Potok 8579, 8640
Revermun 8661
TMK22 8579, 8639
Uluchshennyi 8661
Verlioka 8641
Zoren' 8579, 8636, 8638
- Lycopersicon hirsutum**
genetics
Helicoverpa armigera 8663
Leptinotarsa decemlineata 8663
protoplasts 8654
- Lycopersicon pennellii**
interspecific hybridization 8643
mitochondrial genetics 8643
protoplast fusion 8643
- Lycopersicon peruvianum**
anatomy 8649
fruits 8649
in vitro selection
insects 8664
nystatin 8664
sterols 8664
seeds 8649
- Lycopersicon** (X) **Solanum**, protoplast
fusion 7817
- Lysine**
triticale 7993
Zea mays 8046, 8049, 8051, 8053
genetic variance 8048
in vitro selection 8050
- Macrophomina phaseolina**, *Zea mays* 8059
- Malate dehydrogenase**, *Helianthus annuus*.
genetics 8369
- Male sterility** (see also Cytoplasmic male
sterility)
Beta vulgaris, sugarbeet 8317
Helianthus annuus 8365
Hevea brasiliensis 8401
Oryza sativa 8136
- Malus pumila**
apple mosaic ilarvirus 8414
ascorbic acid 8412
Monilinia laxa 8413
quality 8408-8411
variety trials 8406
varieties 8413
Empress 8407
LyseGold 8410
Melodie 8411
Poe I 8411
PureGold 8410
- Manganese**
Glycine max 8737
Triticum aestivum 7947
- Mangifera**, genetic resources 8404
- Mangifera indica**
kanamycin 8469
tissue culture 8469
- Mannitol**, *Triticum aestivum* 7972
- Maternal effects**, *Oryza sativa*, apomixis
8138
- Mayetiola destructor**
Triticum aestivum
genetics 7979
germplasm releases 7957
- Mechanical harvesting**
Gossypium hirsutum 8279
Phaseolus vulgaris, artificial selection
8687
Solanum tuberosum 8233
- Medicago falcata**
breeding 8190
varieties, Yakutskaya Zheltaya 8190
- Medicago sativa**
combining ability
Fusarium oxysporum 8201
Fusarium solani 8201
Gibberella fujikuroi 8201
cytoplasmic inheritance
cytoplasmic inclusions 8195
pollen 8195
gene expression, *Colletotrichum lindemuthianum* 8202
genetic transformation 8194
genetics, self compatibility 8196
homozygosity 8192
in vitro selection
Fusarium oxysporum 8200
Fusarium solani 8200
Gibberella avenacea 8200
inbreeding 8192
inbreeding depression 8191
induced mutations, self compatibility
8196
techniques
embryo sac 8197
Fusarium 7809
protoplasts 8198-8199
sterility 8197
variety trials 8193
varieties, K6733 8193
- Meliosis** 7826
(see also Chromosome pairing)
Aegilops X *Triticum* 7877
Hevea brasiliensis 8401
Hordeum X *Secale*, nucleocytoplasmic
interaction 7853
Hordeum X *Triticum*, nucleocytoplasmic
interaction 7853
Secale cereale
mutations 7999
nucleocytoplasmic interaction 7853
Secale X *Triticum* 7889, 7893
Triticum aestivum 7893-7894
- Triticum aestivum** *cont.*
nucleocytoplasmic interaction 7853
- Zea mays**
genetics 8033
mutations 8033
- Melampsora populnea**, *Pinus pinaster*.
techniques 8570
- Melilotus alba**
artificial selection, salinity 8211
techniques, salinity 8211
- Melilotus dentata**
artificial selection, salinity 8211
techniques, salinity 8211
- Melilotus officinalis**
artificial selection, salinity 8211
techniques, salinity 8211
- Melissa officinalis**
essential oils 8388
terpenoids 8388
- Meloidogyne**
Lycopersicon esculentum 8662
Prunus 8453
- Meloidogyne incognita**, *Prunus persica*, *in vitro* selection 8450
- Methabenzthiazuron**, *Allium cepa* 7825
- Methylarsonic acid**, *Saccharum* 8306
- N-methyl-N-nitrosourea**
Gossypium 8246
Triticum aestivum 7883, 7916
Triticum durum 7883
- Metoxuron**, *Triticum dicoccoides* 7980
- Micropropagation** (see *In vitro* culture;
Tissue culture)
- Microtermes**, *Oryza sativa* 8166
- Mildews**, *Cucumis sativus* 8630
- Mimulus guttatus**
flowers 8788
pollination 8788
self compatibility 8788
- Mitochondria**
Aegilops X *Triticum* 7892
Triticum aestivum 7892
- Mitochondrial genetics**
Lycopersicon esculentum 8643
Lycopersicon pennellii 8643
- Mitosis** (see Cell division)
- Mitotic recombination**, *Glycine max*, chlorophyll 8706
- Mixoploidy**
Beta vulgaris, sugarbeet 8315
Hippophae rhamnoides 8472
Morus 8467
- Modifiers**, *Ribes*, black currants, *Sphaerotheca mors-uvae* 8515
- Moisture content**, *Zea mays*, combining
ability 8039
- Molecular genetics** 7813, 7817
(see also Chloroplast genetics; Mitochondrial
genetics)
conferences 8837
Glycine max
glycinin 8699
growth regulators 8708
Glycine soja, glycinin 8699
Hordeum vulgare, hordein 8071-8072
Lycopersicon esculentum, alcohol
dehydrogenase 8647
ornamental plants
colour, reviews 8778
flavonoids, reviews 8778
flowers, reviews 8778
Oryza sativa, chitinase 8134
Persea americana, cellulase 8682
Phaseolus vulgaris, cellulase 8682
Prunus persica, fruits 8442
Raphanus sativus, leghaemoglobin
8587
Secale cereale, secalin 7867
Secale X *Triticum*, secalin 7867
Solanum tuberosum, self incompatibility
8226
techniques 7814
Triticum aestivum, secalin 7867
vicilin 7815
Zea mays 8020-8021
heat shock 8057
zein 8018
- Monilia** (see also *Monilinia*)
- Monilinia laxa**, *Malus pumila* 8413

Monogerm seeds

- Beta vulgaris*
sugarbeet 8312, 8317
genetics 8318

Monoploidy (see Haploidy)**Monosomic analysis (see Gene location)****Monosomics (see Aneuploidy)****Monoterpenes, *Pinus monticola* 8566****Morphology**

- Trifolium repens* 8204
Vitis 8530

Morus

- aneuploidy 8466
Bombyx 8464
breeding 8464
chromosome morphology 8467
chromosome pairing 8465
DNA 8468
habit 8467
height 8467
mixoploidy 8467
polyploidy 8465-8468

Multiline varieties (see also Genotype mixtures)**Multiple alleles**

- Beta vulgaris*, sugarbeet, alcohol dehydrogenase 8319-8320
self incompatibility 7829

Multivariate analysis

- Beta vulgaris*, sugarbeet 8321
Cicer arietinum 8766

Mung bean yellow mosaic geminivirus., *Vigna radiata*, induced mutations 8694**Musa, varieties 8471****Musa violascens**

- cryopreservation 7843
genetic resources 7843

Mutagens

- Allium cepa* 7825
Allium fistulosum 7827
Beta vulgaris, sugarbeet 8322
Capsicum annuum 8669
Cassia angustifolia 8400
Citrus limon 8461
Gossypium 8246, 8286
Hordeum vulgare 7827, 8075
Lens culinaris 8768
Lycopersicon esculentum 8647
Secale × *Triticum* 7991
Sorghum sudanense 8127
triticale 7991
Triticum aestivum 7827, 7881-7883, 7916, 7991
Triticum durum 7883
Zea mays 8018, 8025, 8027, 8041

Mutations (see also Back mutations; Chromosome aberrations; Induced mutations)

- Beta vulgaris*, sugarbeet, unreduced gametes 8316
Cicer arietinum, fruits 8765
Glycine max, anthocyanins 8705
Gossypium hirsutum, height 8249
Helianthus annuus
chlorophyll 8368
β-galactosidase 8368
β-glucosidase 8368
Hordeum vulgare, inflorescences 8077, 8083
Hordeum × *Triticum*, chromosome pairing 7873
Lycopersicon esculentum
colour 8650
flowers 8651
gibberellins 8646
inflorescences 8650
roots 8646
ornamental conifers, height 8826
Pinus sylvestris, isoenzymes 8560
proteins 7823
Secale cereale
asynapsis 8000
meiosis 7999
Solanum tuberosum, self incompatibility 8226
triticale, pairing 7987
Triticum aestivum, books 7885
Zea mays 8026
crossing over 8032
habit 8032

Mutations cont.***Zea mays* cont.**

- meiosis 8033
proteinases 8055
zein 8055
Mycorrhizas, genetics, reviews 7842
Mycosphaerella (see also Didymella)
Mycosphaerella graminicola, *Triticum aestivum* 7958
Mycotoxins, *Triticum aestivum* 7963
***Narcissus cantabricus*, cytology 8801**
***Narcissus hedraeanthus*, cytology 8801**
***Neodiprion eduliculis, Pinus edulis* 8571**
Neutron radiation, *Gossypium* 8262
***Nicotiana, Erysiphe cichoracearum* 8341**
Nicotiana sylvestris
heat resistance 8338
heat shock 8338
salinity 8338
Nicotiana tabacum
DNA 8337
gene expression 8333
phosphoenolpyruvate carboxylase 8123
genetic transformation 7840, 8332-8334
δ-endotoxin 8335
phosphoenolpyruvate carboxylase 8123
in vitro selection, salinity 8339
insects 8335
light 8336
***Phytophthora nicotianae* 8340**
proline 8339
protoplasts 8337
tissue culture 8336-8337
ultraviolet radiation 8337
***Nicotiana* (×) *Petunia*, protoplast fusion 7817**
***Nilaparvata lugens, Oryza sativa* 8164**
Nitrate reductase
Triticum aestivum 7955
Triticum durum 7955
Nitrogen
Aegilops 7925
Beta vulgaris, sugarbeet 8330
Hordeum vulgare 8099-8100
Pinus taeda 8564
Triticum 7925
Triticum aestivum, pleiotropy 7921
Zea mays 8051
Nitrogen fixation
Pisum sativum 8749
Triticum aestivum 7949-7950
Nitrogenase, *Triticum aestivum* 7950
Nitroso compounds, *Zea mays* 8027
Nucleocytoplasmic interaction
Aegilops × *Triticum*, tissue culture 7933
Agropyron × *Triticum*, tissue culture 7933
Brassica
rape
isoenzymes 8349
peroxidases 8349
proline 8349
Hordeum vulgare, salinity 8103
Hordeum × *Secale*, meiosis 7853
Hordeum × *Triticum*, meiosis 7853
Secale cereale, meiosis 7853
Secale × *Triticum*
aneuploidy 7895
chromosome pairing 7875, 7895
sterility 7875
Triticum aestivum
aneuploidy 7895
chromosome pairing 7895
meiosis 7853
Puccinia recondita 7968
tissue culture 7933
yields 7922
Nucleolus, *Hordeum* × *Secale* 7998
Nucleolus organizer
Secale cereale 7852
Triticum aestivum 7852
Triticum durum 7852
Nullisomic analysis (see Gene location)
Nutrients
Aegilops 7925
Beta vulgaris, sugarbeet 8330
Hordeum vulgare 8099-8100
Oryza sativa 8153

Nutrients cont.***Oryza sativa* cont.**

- genetic variance 8154
Pinus taeda 8564
Prunus, peaches 8444
Triticum 7925
Triticum aestivum 7947
pleiotropy 7921
Zea mays 8051
Nutritive value
Brassica
rape 8357
turnip rape 8357
cereals, genetic engineering 7844
Glycine max 8727
grain legumes, genetic engineering 7844
Nystatin, *Lycopersicon peruvianum*, in vitro selection 8664
Oil plants, breeding 8838
Oils
Arachis hypogaea 8345
Brassica 8345
rape
genetic variance 8353
heritability 8353
Carthamus tinctorius 8345
Glycine max 8345, 8724-8725, 8734
genotype environment interaction 8711
Gossypium barbadense, combining ability 8276
Helianthus annuus 8345
Linum usitatissimum, linseed 8345
Zea mays 8046
Olea europaea
abnormal development 8378
flowers 8378
gene banks 8377
genetic resources 8377
Onobrychis arenaria
chromosome banding 8209
chromosome morphology 8209
taxonomy 8209
Onobrychis montana
chromosome banding 8209
chromosome morphology 8209
taxonomy 8209
Onobrychis viciifolia
chromosome banding 8209
chromosome morphology 8209
protoplasts 8210
taxonomy 8209
tissue culture 8210
***Ophiobolus* (see *Gaeumannomyces*)**
Organic acids, *Eriobotrya japonica* 8422
Ornamental conifers
cuttings 8826
mutations, height 8826
Ornamental plants
breeding 8776
genetics
colour, reviews 8778
flavonoids, reviews 8778
flowers, reviews 8778
molecular genetics
colour, reviews 8778
flavonoids, reviews 8778
flowers, reviews 8778
quality 8777
Ornamental value, *Capsicum annuum* 8668
Ornamental woody plants
genetic resources 8817
plant introduction 8816-8817
Ornithopus compressus
varieties
Madeira 8216
Paros 8216
***Orseolia oryzae, Oryza sativa* 8165**
Oryza glaberrima
Pyricularia oryzae 8161
varieties 8161
Oryza sativa
anoxia 8144
anther culture 8148, 8150
breeding 8129, 8131
combining ability, yield components 8146
compatibility 8130
cutting 8155
Cyrtorhinus lividipennis 8164

- Oryza sativa** *cont.*
 cytoplasm 8131
 drought resistance 8157
 enzymes 8144
 fertility 8136
 flooding 8145
 gamma radiation 8150
 gene expression
 chitinase 8134
 cold 7856
 genetic markers, apomixis 8138
 genetic variance, nutrients 8154
 genetics
 apomixis 8138
 cytoplasmic male sterility 8137
 isoenzymes 8148
Xanthomonas campestris 8130, 8159
 germination 8139, 8144
 heritability, seedlings 8141
 heterosis, yield components 8146
 leaves 8142-8143
 linkage
 isoenzymes 8148
Xanthomonas campestris 8130
 male sterility 8136
 maternal effects, apomixis 8138
Microtermes 8166
 molecular genetics, chitinase 8134
Nilaparvata lugens 8164
 nutrients 8153
Orseolia oryzae 8165
 phosphorus 8153
 photosynthesis 8140
 protoplasts 8147
Pyricularia oryzae 8158, 8162
 quality 8152
 regenerative ability 8151
Rhizoctonia solani 8158, 8160
Sogatella furcifera 8163
 stomata 8140
 tissue culture 8149, 8151
 toxic substances 8156
 transgression, yield components 8135
 twinning 8139
Ustilagoidea virens 8158
 vascular system 8142
 wide hybridization 8130, 8135
Xanthomonas campestris 8158
 yield components 8155
 yield correlations 8143, 8145
 varieties 8159
 Haomei 8130
 IET9710 8158
 IR28 8154
 IR30864 8132
 Khonorullo 8154
 Mandyavijaya 8132
 Mirikrak 8154
 Neela 8165
 Samalie 8165
 Sarasa 8165
 Savithri 8158
 Slavyanets 8133
 W6154S 8146
 W6184S 8146
- Outcrossing, *Pinus sylvestris*** 8562
- Overdominance (see Heterosis)**
- Ovule culture**
Beta vulgaris, sugarbeet 8325
Lilium 8806
- Pairing**
 triticale
 genetics 7987
 mutations 7987
- Palatability, *Prunus persica*** 8443
- Panax pseudoginseng***, embryo culture 8396
- Pandanus***, evolution, reproduction 8549
- Panicum miliaceum***
 centres of origin 8114
 chemotaxonomy 8114
 esterases 8114
 hybridization 8111
 induced mutations 8112
 isoenzymes 8114
 temperature 8111
- Panicum psilopodium***
 chromosome pairing 8113
 interspecific hybridization 8113
- Panicum sumatrense***
 chromosome pairing 8113
- Panicum sumatrense* *cont.***
 interspecific hybridization 8113
- Papaver***, alkaloids 8395
- Papaver somniferum***
 variety trials 8391
 varieties
 Amarin 8391
 R1 8391
 R8 8391
- Paphiopedilum***, breeding 8815
- Parthenocarpy**
Carica papaya 8477
Cucumis sativus 8625
- Patatin, *Solanum tuberosum***, gene expression 8225
- Pennisetum americanum***
 genetics
 phenol 8116
 seeds 8116
Puccinia substriata 8117
- Peronospora schachtii***, *Beta vulgaris*, sugarbeet 8327-8328
- Peroxidases**
Beta vulgaris, sugarbeet, genetic markers 8325
Brassica, rape, nucleocytoplasmic interaction 8349
Cucumis sativus 8634
Hordeum vulgare, genetics 8088
Saccharum officinarum 8300
- Persea americana***, molecular genetics, cellulase 8682
- Petunia* (X) *Nicotiana***, protoplast fusion 7817
- Phalaris aquatica***, varieties, Holdfast 8183
- Phaseolin**
Phaseolus coccineus, gene location 8683
Phaseolus vulgaris
 artificial selection 8685-8686
 genetics 8686
- Phaseolus* (see also *Vigna*)**
- Phaseolus coccineus***
 cold resistance 8688
 gene location, phaseolin 8683
 germination 8688
- Phaseolus ritensis***
 cold resistance 8688
 germination 8688
- Phaseolus vulgaris***
 artificial selection
 mechanical harvesting 8687
 phaseolin 8685-8686
 yield components 8681
 cold resistance 8688
 genetics, phaseolin 8686
 germination 8688
 linkage
 isoenzymes 8684
 seeds 8684
 molecular genetics, cellulase 8682
 varieties, Rampicante Scarlatto 8688
- Phenol, *Pennisetum americanum***, genetics 8116
- Phenolic compounds, *Prunus persica*** 8443
- Phleum pratense***, breeding 8176
- Phoenix dactylifera***, salinity 8476
- Phoma* (see also *Deuterophoma*; *Leptosphaeria*)**
 Solanaceae 8635
 vegetables 8635
- Phomopsis* (see also *Diaporthe*)**
- Phomopsis phaseoli***, *Glycine max* 8741
- Phosphoenolpyruvate carboxylase**
Nicotiana tabacum
 gene expression 8123
 genetic transformation 8123
- Sorghum bicolor***
 gene expression 8123
 genetic engineering 8123
- Phosphoglucanate dehydrogenase**
Helianthus annuus, genetics 8369
Hordeum vulgare, genetics 8088
- Phosphorus**
Glycine max 8726
Oryza sativa 8153
- Photoperiodism**
Glycine max, techniques 8715
Hordeum vulgare, genetics 8089
Solanum berthaultii 8229
Solanum tuberosum 8229
- Photoperiodism *cont.***
Triticum aestivum 7907
 artificial selection 7914
 gene location 7908
- Photosynthesis**
Cajanus cajan 8770
Gossypium barbadense 8256
Gossypium hirsutum 8256, 8267
Oryza sativa 8140
Trifolium pratense 8203
- Phyllosticta (see also *Ascochyta*; *Mycosphaerella*)**
- Phylogeny (see Evolution)**
- Physoalospora* (see also *Glomerella*)**
- Phytic acid, *Glycine max*** 8726
- Phytophthora capsici***, *Capsicum* 8675
- Phytophthora fragariae***, *Fragaria ananassa* 8525
- Phytophthora infestans***
Solanum, tuberosus species 8237
Solanum tuberosum 8233, 8238
- Phytophthora megasperma***
Cicer arietinum 8767
Glycine max 8740
- Phytophthora nicotianae***
Lycopersicon esculentum
 genetic variance 8660
 genetics 8660
Nicotiana tabacum 8340
- Picea abies***
 breeding 8538, 8556
 isoenzymes 8556
- Pinus***
 enzymes 8569
 evolution 8569
 isoenzymes 8569
 proteins 8569
- Pinus edulis***, *Neodiprion edulicolis* 8571
- Pinus koraiensis***, genetics, seedlings 8567
- Pinus monticola***
 geography 8566
 heritability
 height 8565
 yield components 8565
 monoterpenes 8566
- Pinus pinaster***, techniques, *Melampsora populnea* 8570
- Pinus sibirica***
 breeding 8556-8557
 genetic distance
 enzymes 8561
 isoenzymes 8561
 genetics, isoenzymes 8568
 isoenzymes 8556
 linkage, isoenzymes 8568
 polymorphism
 enzymes 8561
 isoenzymes 8561
- Pinus sylvestris***
 breeding 8538, 8556, 8558
 development 8558
 genetic distance 8559
 germination 8558
 isoenzymes 8556, 8559
 mutations, isoenzymes 8560
 outcrossing 8562
 radiation 8560
 radionuclides 8560
 recombination, isoenzymes 8560
 seed production 8558
- Pinus taeda***
 growth period 8563
 nitrogen 8564
 nutrients 8564
 specific gravity 8563
 translocation 8564
- Piper nigrum***, diseases 8389
- Pisum sativum***
 abscisic acid 8756
 acetyl CoA-carboxylase 8753
Acyrtosiphon pisum 8763
 breeding 8189, 8749, 8760
 canopy 8752
 crop density 8758
 crossing over 8750
 2,4-D 8756
 genetic transformation 8748, 8761
 genetics
 determinate and indeterminate habit 8757
 histones 8755

- Pollination cont.**
Mimulus guttatus 8788
Verbena hastata 8789
Verbena stricta 8789
Verbena urticifolia 8789
Zea mays, techniques 8011
Polymorphism (*see also* Twinning)
Polymorphism (*see* Haplotype)
Polymorphism
Beta vulgaris
sugarbeet
alcohol dehydrogenase 8320
Helianthus annuus
globulins 8367
helianthinin 8367
Larix sibirica, enzymes 8574
Pinus sibirica
enzymes 8561
isozymes 8561
Setaria, prolamins 8115
Triticum aestivum, glutenins 7915
Polyploidy
Alopocurus aequalis 8184
Anigostaphylos 8787
Beta vulgaris
fodder beet 8219
sugarbeet 8312, 8314, 8317
Boehmeria nivea 8296
fodder legumes 8169
Fragaria, reviews 8523
Glycine 8707
grasses 8169
Hordeum vulgare 8095
Lilium 8802
Lycium barbarum 8393
Morus 8465-8468
Pinus satsumensis 8678
Rubus, raspberries 8497
Solanum, tuberous species 8228
Sorghum bicolor 8124
Vicia faba 8680
Vigna mungo 8693
Vigna radiata 8693
Polysaccharides, Zea mays 8060
Polysomaty (*see* Mixoploidy)
Polysomies (*see* Aneuploidy)
Ponticus × Citrus
intergeneric hybridization 8455-8456
interspecific hybridization 8454
Populus trichocarpa, Xanthomonas populi
8541
Porphyra yezoensis, chloroplast genetics
8775
Potato A polystyrene, Solanum tuberosum
8240
Potato leaf roll luteovirus, Solanum tuberosum
8239-8241
Potato M carlavirus
Solanum megistacrolobum, genetics
8239
Potato S carlavirus, Solanum tuberosum
8240
Potato X potexvirus
Lycopersicon esculentum 8661
Solanum tuberosum 8240-8241
genetic transformation 8223
Potato Y polystyrene
Solanum tuberosum 8239
Solanum stoloniferum 8239
genetic transformation 8223
Prolamins
Dactylis glomerata 8175
Setaria, polymorphism 8115
Brassica, rape, nucleocytoplasmic inter-
action 8349
Lolium 8177
Nicotiana tabacum 8339
Prometyn, Zea mays 8046
Propazine
Pinus satsumensis, in vitro selection 8678
Vicia faba, in vitro selection 8678
Proteinase
Zea mays
genes 8055
mutations 8055
Proteins
Aegilops × Triticum 7877
Brassica
rape
genetic variance 8350
heritability 8350
Capistum annuum 8676
Glycine max 8724-8725
techniques 8730
Gossypium hirsutum 8278
Hordeum vulgare 8100
mutations 7823
Pinus 8569
critical 7993
genetic variance 7992
Triticum aestivum 7903, 7937
chromosome substitution 7890
gene location 7945
Triticum dicoccoides 7903
Triticum durum 7903, 7937
Zea mays 8053-8054
genetic variance 8048
Protoplast fusion 7817
Brassica, cauliflower 8603
Glycine max 8719
Lactuca debilis 8606
Lactuca indica 8606
Lactuca sativa 8606
Lycopersicon esculentum 8643
Lycopersicon pennsylvanicum 8643
Lycopersicon (*×*) *Solanum* 7817
Petunia (*×*) *Nicotiana* 7817
Nicotiana (*×*) *Petunia* 7817
Lycopersicon (*×*) *Solanum* 7817
Protoplasts
Brassica, rape, techniques 8355
Glycine max 8716-8717, 8719, 8721-8722
Glycine soja 8716, 8718
Helianthus annuus 8370
Hordeum vulgare 8093
Lactuca debilis 8606
Lactuca indica 8606
Lactuca sativa 8606
Lycopersicon hirsutum 8654
Medicago sativa, techniques 8198-8199
Nicotiana glauca 8337
Onobrychis viciifolia 8210
Oryza sativa 8147
Solanum dulcissimum, techniques 8399
Solanum tuberosum 8231
Prunus
chemotaxonomy 8425
Citronella xanthoxanthum 8437
interspecific hybridization 8425
isozymes 8425
Meloidogyne 8453
Pseudomonas syringae 8437
rootstocks 8437, 8453
genetics, isozymes 8424
interspecific hybridization 8453
apricots
genetic resources 8423
quality 8423
cherries
interspecific hybridization 8428
quality 8429
Kordia 8429
varieties
Prunus
Solanum tuberosum 8231
Solanum dulcissimum, techniques 8399
Oryza sativa 8147
Onobrychis viciifolia 8210
Nicotiana glauca 8337
Medicago sativa, techniques 8198-8199
Lycopersicon hirsutum 8654
Lactuca sativa 8606
Lactuca indica 8606
Lactuca debilis 8606
Hordeum vulgare 8093
Helianthus annuus 8370
Glycine soja 8716, 8718
Glycine max 8716-8717, 8719, 8721-8722
Brassica carinata 8354
Brassica, rape, techniques 8355
Plant introduction
ornamental woody plants 8816-8817
Rubus 8482
Plant embryo, Hordeum × Secale 8074
Rubus idaeus 8502
Glycine max 8726
Capistum 8675
Beta vulgaris, sugarbeet 8330
Allium cepa 8593
Plant composition
Plant collections (*see* Gene banks)
Yuzhnyi 8579
Voronozhskii-Zelenyi 8579
Krasnogradskii-7 8760
Krasnogradskii-6 8760
Beta vulgaris
fodder beet 8219
sugarbeet 8312, 8314, 8317
Boehmeria nivea 8296
fodder legumes 8169
Fragaria, reviews 8523
Glycine 8707
grasses 8169
Hordeum vulgare 8095
Lilium 8802
Lycium barbarum 8393
Morus 8465-8468
Pinus satsumensis 8678
Rubus, raspberries 8497
Solanum, tuberous species 8228
Sorghum bicolor 8124
Vicia faba 8680
Vigna mungo 8693
Vigna radiata 8693
Polysaccharides, Zea mays 8060
Polysomaty (*see* Mixoploidy)
Polysomies (*see* Aneuploidy)
Ponticus × Citrus
intergeneric hybridization 8455-8456
interspecific hybridization 8454
Populus trichocarpa, Xanthomonas populi
8541
Porphyra yezoensis, chloroplast genetics
8775
Potato A polystyrene, Solanum tuberosum
8240
Potato leaf roll luteovirus, Solanum tuberosum
8239-8241
Potato M carlavirus
Solanum megistacrolobum, genetics
8239
Potato S carlavirus, Solanum tuberosum
8240
Potato X potexvirus
Lycopersicon esculentum 8661
Solanum tuberosum 8240-8241
genetic transformation 8223
Potato Y polystyrene
Solanum tuberosum 8239
Solanum stoloniferum 8239
genetic transformation 8223
Prolamins
Dactylis glomerata 8175
Setaria, polymorphism 8115
Brassica, rape, nucleocytoplasmic inter-
action 8349
Lolium 8177
Nicotiana tabacum 8339
Prometyn, Zea mays 8046
Propazine
Pinus satsumensis, in vitro selection 8678
Vicia faba, in vitro selection 8678
Proteinase
Zea mays
genes 8055
mutations 8055
Proteins
Aegilops × Triticum 7877
Brassica
rape
genetic variance 8350
heritability 8350
Capistum annuum 8676
Glycine max 8724-8725
techniques 8730
Gossypium hirsutum 8278
Hordeum vulgare 8100
mutations 7823
Pinus 8569
critical 7993
genetic variance 7992
Triticum aestivum 7903, 7937
chromosome substitution 7890
gene location 7945
Triticum dicoccoides 7903
Triticum durum 7903, 7937
Zea mays 8053-8054
genetic variance 8048
Protoplast fusion 7817
Brassica, cauliflower 8603
Glycine max 8719
Lactuca debilis 8606
Lactuca indica 8606
Lactuca sativa 8606
Lycopersicon esculentum 8643
Lycopersicon pennsylvanicum 8643
Lycopersicon (*×*) *Solanum* 7817
Petunia (*×*) *Nicotiana* 7817
Nicotiana (*×*) *Petunia* 7817
Lycopersicon (*×*) *Solanum* 7817
Protoplasts
Brassica, rape, techniques 8355
Glycine max 8716-8717, 8719, 8721-8722
Glycine soja 8716, 8718
Helianthus annuus 8370
Hordeum vulgare 8093
Lactuca debilis 8606
Lactuca indica 8606
Lactuca sativa 8606
Lycopersicon hirsutum 8654
Medicago sativa, techniques 8198-8199
Nicotiana glauca 8337
Onobrychis viciifolia 8210
Oryza sativa 8147
Solanum dulcissimum, techniques 8399
Solanum tuberosum 8231
Prunus
chemotaxonomy 8425
Citronella xanthoxanthum 8437
interspecific hybridization 8425
isozymes 8425
Meloidogyne 8453
Pseudomonas syringae 8437
rootstocks 8437, 8453
genetics, isozymes 8424
interspecific hybridization 8453
apricots
genetic resources 8423
quality 8423
cherries
interspecific hybridization 8428
quality 8429
Kordia 8429
varieties
Prunus
Solanum tuberosum 8231
Solanum dulcissimum, techniques 8399
Oryza sativa 8147
Onobrychis viciifolia 8210
Nicotiana glauca 8337
Medicago sativa, techniques 8198-8199
Lycopersicon hirsutum 8654
Lactuca sativa 8606
Lactuca indica 8606
Lactuca debilis 8606
Hordeum vulgare 8093
Helianthus annuus 8370
Glycine soja 8716, 8718
Glycine max 8716-8717, 8719, 8721-8722
Brassica carinata 8354
Brassica, rape, techniques 8355
Plant introduction
ornamental woody plants 8816-8817
Rubus 8482
Plant embryo, Hordeum × Secale 8074
Rubus idaeus 8502
Glycine max 8726
Capistum 8675
Beta vulgaris, sugarbeet 8330
Allium cepa 8593
Plant composition
Plant collections (*see* Gene banks)
Yuzhnyi 8579
Voronozhskii-Zelenyi 8579
Krasnogradskii-7 8760
Krasnogradskii-6 8760
Beta vulgaris
fodder beet 8219
sugarbeet 8312, 8314, 8317
Boehmeria nivea 8296
fodder legumes 8169
Fragaria, reviews 8523
Glycine 8707
grasses 8169
Hordeum vulgare 8095
Lilium 8802
Lycium barbarum 8393
Morus 8465-8468
Pinus satsumensis 8678
Rubus, raspberries 8497
Solanum, tuberous species 8228
Sorghum bicolor 8124
Vicia faba 8680
Vigna mungo 8693
Vigna radiata 8693
Polysaccharides, Zea mays 8060
Polysomaty (*see* Mixoploidy)
Polysomies (*see* Aneuploidy)
Ponticus × Citrus
intergeneric hybridization 8455-8456
interspecific hybridization 8454
Populus trichocarpa, Xanthomonas populi
8541
Porphyra yezoensis, chloroplast genetics
8775
Potato A polystyrene, Solanum tuberosum
8240
Potato leaf roll luteovirus, Solanum tuberosum
8239-8241
Potato M carlavirus
Solanum megistacrolobum, genetics
8239
Potato S carlavirus, Solanum tuberosum
8240
Potato X potexvirus
Lycopersicon esculentum 8661
Solanum tuberosum 8240-8241
genetic transformation 8223
Potato Y polystyrene
Solanum tuberosum 8239
Solanum stoloniferum 8239
genetic transformation 8223
Prolamins
Dactylis glomerata 8175
Setaria, polymorphism 8115
Brassica, rape, nucleocytoplasmic inter-
action 8349
Lolium 8177
Nicotiana tabacum 8339
Prometyn, Zea mays 8046
Propazine
Pinus satsumensis, in vitro selection 8678
Vicia faba, in vitro selection 8678
Proteinase
Zea mays
genes 8055
mutations 8055
Proteins
Aegilops × Triticum 7877
Brassica
rape
genetic variance 8350
heritability 8350
Capistum annuum 8676
Glycine max 8724-8725
techniques 8730
Gossypium hirsutum 8278
Hordeum vulgare 8100
mutations 7823
Pinus 8569
critical 7993
genetic variance 7992
Triticum aestivum 7903, 7937
chromosome substitution 7890
gene location 7945
Triticum dicoccoides 7903
Triticum durum 7903, 7937
Zea mays 8053-8054
genetic variance 8048
Protoplast fusion 7817
Brassica, cauliflower 8603
Glycine max 8719
Lactuca debilis 8606
Lactuca indica 8606
Lactuca sativa 8606
Lycopersicon esculentum 8643
Lycopersicon pennsylvanicum 8643
Lycopersicon (*×*) *Solanum* 7817
Petunia (*×*) *Nicotiana* 7817
Nicotiana (*×*) *Petunia* 7817
Lycopersicon (*×*) *Solanum* 7817
Protoplasts
Brassica, rape, techniques 8355
Glycine max 8716-8717, 8719, 8721-8722
Glycine soja 8716, 8718
Helianthus annuus 8370
Hordeum vulgare 8093
Lactuca debilis 8606
Lactuca indica 8606
Lactuca sativa 8606
Lycopersicon hirsutum 8654
Medicago sativa, techniques 8198-8199
Nicotiana glauca 8337
Onobrychis viciifolia 8210
Oryza sativa 8147
Solanum dulcissimum, techniques 8399
Solanum tuberosum 8231
Prunus
chemotaxonomy 8425
Citronella xanthoxanthum 8437
interspecific hybridization 8425
isozymes 8425
Meloidogyne 8453
Pseudomonas syringae 8437
rootstocks 8437, 8453
genetics, isozymes 8424
interspecific hybridization 8453
apricots
genetic resources 8423
quality 8423
cherries
interspecific hybridization 8428
quality 8429
Kordia 8429
varieties
Prunus
Solanum tuberosum 8231
Solanum dulcissimum, techniques 8399
Oryza sativa 8147
Onobrychis viciifolia 8210
Nicotiana glauca 8337
Medicago sativa, techniques 8198-8199
Lycopersicon hirsutum 8654
Lactuca sativa 8606
Lactuca indica 8606
Lactuca debilis 8606
Hordeum vulgare 8093
Helianthus annuus 8370
Glycine soja 8716, 8718
Glycine max 8716-8717, 8719, 8721-8722
Brassica carinata 8354
Brassica, rape, techniques 8355
Plant introduction
ornamental woody plants 8816-8817
Rubus 8482
Plant embryo, Hordeum × Secale 8074
Rubus idaeus 8502
Glycine max 8726
Capistum 8675
Beta vulgaris, sugarbeet 8330
Allium cepa 8593
Plant composition
Plant collections (*see* Gene banks)
Yuzhnyi 8579
Voronozhskii-Zelenyi 8579
Krasnogradskii-7 8760
Krasnogradskii-6 8760
Beta vulgaris
fodder beet 8219
sugarbeet 8312, 8314, 8317
Boehmeria nivea 8296
fodder legumes 8169
Fragaria, reviews 8523
Glycine 8707
grasses 8169
Hordeum vulgare 8095
Lilium 8802
Lycium barbarum 8393
Morus 8465-8468
Pinus satsumensis 8678
Rubus, raspberries 8497
Solanum, tuberous species 8228
Sorghum bicolor 8124
Vicia faba 8680
Vigna mungo 8693
Vigna radiata 8693
Polysaccharides, Zea mays 8060
Polysomaty (*see* Mixoploidy)
Polysomies (*see* Aneuploidy)
Ponticus × Citrus
intergeneric hybridization 8455-8456
interspecific hybridization 8454
Populus trichocarpa, Xanthomonas populi
8541
Porphyra yezoensis, chloroplast genetics
8775
Potato A polystyrene, Solanum tuberosum
8240
Potato leaf roll luteovirus, Solanum tuberosum
8239-8241
Potato M carlavirus
Solanum megistacrolobum, genetics
8239
Potato S carlavirus, Solanum tuberosum
8240
Potato X potexvirus
Lycopersicon esculentum 8661
Solanum tuberosum 8240-8241
genetic transformation 8223
Potato Y polystyrene
Solanum tuberosum 8239
Solanum stoloniferum 8239
genetic transformation 8223
Prolamins
Dactylis glomerata 8175
Setaria, polymorphism 8115
Brassica, rape, nucleocytoplasmic inter-
action 8349
Lolium 8177
Nicotiana tabacum 8339
Prometyn, Zea mays 8046
Propazine
Pinus satsumensis, in vitro selection 8678
Vicia faba, in vitro selection 8678
Proteinase
Zea mays
genes 8055
mutations 8055
Proteins
Aegilops × Triticum 7877
Brassica
rape
genetic variance 8350
heritability 8350
Capistum annuum 8676
Glycine max 8724-8725
techniques 8730
Gossypium hirsutum 8278
Hordeum vulgare 8100
mutations 7823
Pinus 8569
critical 7993
genetic variance 7992
Triticum aestivum 7903, 7937
chromosome substitution 7890
gene location 7945
Triticum dicoccoides 7903
Triticum durum 7903, 7937
Zea mays 8053-8054
genetic variance 8048
Protoplast fusion 7817
Brassica, cauliflower 8603
Glycine max 8719
Lactuca debilis 8606
Lactuca indica 8606
Lactuca sativa 8606
Lycopersicon esculentum 8643
Lycopersicon pennsylvanicum 8643
Lycopersicon (*×*) *Solanum* 7817
Petunia (*×*) *Nicotiana* 7817
Nicotiana (*×*) *Petunia* 7817
Lycopersicon (*×*) *Solanum* 7817
Protoplasts
Brassica, rape, techniques 8355
Glycine max 8716-8717, 8719, 8721-8722
Glycine soja 8716, 8718
Helianthus annuus 8370
Hordeum vulgare 8093
Lactuca debilis 8606
Lactuca indica 8606
Lactuca sativa 8606
Lycopersicon hirsutum 8654
Medicago sativa, techniques 8198-8199
Nicotiana glauca 8337
Onobrychis viciifolia 8210
Oryza sativa 8147
Solanum dulcissimum, techniques 8399
Solanum tuberosum 8231
Prunus
chemotaxonomy 8425
Citronella xanthoxanthum 8437
interspecific hybridization 8425
isozymes 8425
Meloidogyne 8453
Pseudomonas syringae 8437
rootstocks 8437, 8453
genetics, isozymes 8424
interspecific hybridization 8453
apricots
genetic resources 8423
quality 8423
cherries
interspecific hybridization 8428
quality 8429
Kordia 8429
varieties
Prunus
Solanum tuberosum 8231
Solanum dulcissimum, techniques 8399
Oryza sativa 8147
Onobrychis viciifolia 8210
Nicotiana glauca 8337
Medicago sativa, techniques 8198-8199
Lycopersicon hirsutum 8654
Lactuca sativa 8606
Lactuca indica 8606
Lactuca debilis 8606
Hordeum vulgare 8093
Helianthus annuus 8370
Glycine soja 8716, 8718
Glycine max 8716-8717, 8719, 8721-8722
Brassica carinata 8354
Brassica, rape, techniques 8355
Plant introduction
ornamental woody plants 8816-8817
Rubus 8482
Plant embryo, Hordeum × Secale 8074
Rubus idaeus 8502
Glycine max 8726
Capistum 8675
Beta vulgaris, sugarbeet 8330
Allium cepa 8593
Plant composition
Plant collections (*see* Gene banks)
Yuzhnyi 8579
Voronozhskii-Zelenyi 8579
Krasnogradskii-7 8760
Krasnogradskii-6 8760
Beta vulgaris
fodder beet 8219
sugarbeet 8312, 8314, 8317
Boehmeria nivea 8296
fodder legumes 8169
Fragaria, reviews 8523
Glycine 8707
grasses 8169
Hordeum vulgare 8095
Lilium 8802
Lycium barbarum 8393
Morus 8465-8468
Pinus satsumensis 8678
Rubus, raspberries 8497
Solanum, tuberous species 8228
Sorghum bicolor 8124
Vicia faba 8680
Vigna mungo 8693
Vigna radiata 8693
Polysaccharides, Zea mays 8060
Polysomaty (*see* Mixoploidy)
Polysomies (*see* Aneuploidy)
Ponticus × Citrus
intergeneric hybridization 8455-8456
interspecific hybridization 8454
Populus trichocarpa, Xanthomonas populi
8541
Porphyra yezoensis, chloroplast genetics
8775
Potato A polystyrene, Solanum tuberosum
8240
Potato leaf roll luteovirus, Solanum tuberosum
8239-8241
Potato M carlavirus
Solanum megistacrolobum, genetics
8239
Potato S carlavirus, Solanum tuberosum
8240
Potato X potexvirus
Lycopersicon esculentum 8661
Solanum tuberosum 8240-8241
genetic transformation 8223
Potato Y polystyrene
Solanum tuberosum 8239
Solanum stoloniferum 8239
genetic transformation 8223
Prolamins
Dactylis glomerata 8175
Setaria, polymorphism 8115
Brassica, rape, nucleocytoplasmic inter-
action 8349
Lolium 8177
Nicotiana tabacum 8339
Prometyn, Zea mays 8046
Propazine
Pinus satsumensis, in vitro selection 8678
Vicia faba, in vitro selection 8678
Proteinase
Zea mays
genes 8055
mutations 8055
Proteins
Aegilops × Triticum 7877
Brassica
rape
genetic variance 8350
heritability 8350
Capistum annuum 8676
Glycine max 8724-8725
techniques 8730
Gossypium hirsutum 8278
Hordeum vulgare 8100
mutations 7823
Pinus 8569
critical 7993
genetic variance 7992
Triticum aestivum 7903, 7937
chromosome substitution 7890
gene location 7945
Triticum dicoccoides 7903
Triticum durum 7903, 7937
Zea mays

- Prunus* cont.**
 plums
 genetic resources 8423
 genetics, isoenzymes 8424
 quality 8423
 waterlogging 8423
 varieties, Queensland Bellerosa 8427
- Prunus armeniaca***
 genetics, isoenzymes 8424
 pollen germination 8426
- Prunus persica***
 cold resistance 8446-8449, 8829
 crop density 8445
 flowering 8438
 gene expression, fruits 8442
 genetic resources 8430
 genetic transformation 8441, 8450
 genetics 8435
 fruits 8439
 isoenzymes 8424
 ripening 8439
 germination 8438
 height 8432
 in vitro culture 8440
 in vitro selection
 Meloidogyne incognita 8450
 Xanthomonas campestris 8450
 interspecific hybridization 8453
Leucostoma cincta 8452
Leucostoma persoonii 8451-8452
 molecular genetics, fruits 8442
 palatability 8443
 phenolic compounds 8443
 rootstocks 8447, 8453
 tissue culture 8441
 variety trials 8431-8432
 varieties
 B612615 8443
 Flordaglobe 8433
 Granite Supreme 8434
 Jefferson 8443
 Late Red 8432
 Red Prolific 8432
 Reliance 8452
 Summered 8432
 V68101 8452
 V75013 8452
- Psathyrostachys fragilis***
 chromosome banding 8076
 genomes 8076
- Psathyrostachys* × *Hordeum***, intergeneric hybridization 8076
- Psathyrostachys* × *Secale***, intergeneric hybridization 7997
- Pseudomonas solanacearum***, *Arachis hypogaea* 8381
- Pseudomonas syringae***
Cucumis sativus 8631
Glycine max 8740
Prunus 8437
Triticum aestivum 7958
- Pseudoperonospora cubensis***
Cucumis sativus 8612, 8630-8631, 8633-8634
Cucurbita 8612
- Puccinia graminis***
Secale cereale
 gene location 7850
 genetics 7850
Triticum 7886
Triticum aestivum 7959, 7972
 gene location 7850
 genetics 7850
 reviews 7973
- Puccinia hordei***, *Hordeum vulgare* 8110
- Puccinia recondita***
Aegilops 7982
Secale cereale
 gene location 7850
 genetics 7850
Triticum 7982
Triticum aestivum 7959, 7961-7962, 7969
 gene location 7850, 7966
 genetics 7850, 7967, 7970-7971, 7974
 genotype mixtures 7960
 germplasm releases 7966
 heterosis 7960
 nucleocytoplasmic interaction 7968
- Puccinia recondita* cont.**
Triticum timopheevii, genetics 7970
- Puccinia striiformis***
Triticum aestivum 7959
 genetics 7965
- Puccinia substriata***, *Pennisetum americanum* 8117
- Pucciniastrum americanum***
Rubus 8505
Rubus idaeus 8505
- Pulses** (see Grain legumes)
- Pure lines** (see Inbreeding)
- Pyrenophora teres***, *Hordeum vulgare*, genetics 8105
- Pyricularia oryzae***
Oryza glaberrima 8161
Oryza sativa 8158, 8162
- Pyrus***
Cacopsylla pyricola 8421
 chromosome number 8416
 evolution 8416
- Pyrus caucasica***, interspecific hybridization 8416
- Pyrus communis***
 cell culture 8418
 cold resistance 8415
 cryopreservation 8419
 2,4-D 8418
 growth regulators 8418
 spur types 8415
 tissue culture 8419-8420
Venturia inaequalis 8415
- Pyrus pseudosyrriaca***, interspecific hybridization 8416
- Pyrus pyrifolia***
 air pollution 8417
 aspartate aminotransferase 8417
 isoenzymes 8417
 pollen 8417
- Pyrus salicifolia***, interspecific hybridization 8416
- Pythium aphanidermatum***, *Cucumis sativus* 8632
- Quality**
Aegilops × *Triticum* 7899
Agave sisalana 8295
Allium cepa 8593
Beta vulgaris, sugarbeet 8326
Citrus × *Poncirus*, artificial selection 8455
Cucumis melo
 combining ability 8614
 heterosis 8614
Cucurbita pepo 8619
Daucus carota 8584
Freesia 8808
Gossypium 8249
 genetic variance 8287
 induced mutations 8248
Gossypium barbadense 8251, 8261
Gossypium hirsutum 8259, 8261, 8288
Lycopersicon esculentum 8655
Malus pumila 8408-8411
 ornamental plants 8777
Oryza sativa 8152
Prunus
 apricots 8423
 cherries 8429
 plums 8423
Rubus 8482
Rubus idaeus 8492
Triticum aestivum 7935-7936, 7941-7942
 techniques 7939, 7943
Triticum durum, artificial selection 7940
Vitis vinifera 8526
- Quantitative genetics**
 statistics 7819
 techniques 7821
- Quercus robur***
 breeding 8540
 development 8540
 habit 8540
 seasonal growth 8540
- Radiation** (see also Gamma radiation; Lasers; Neutron radiation; Ultraviolet radiation)
Gossypium barbadense 8257
Gossypium hirsutum 8257
Hordeum vulgare 8087
- Radiation cont.**
Pinus sylvestris 8560
- Radioactive nuclides** (see Radionuclides)
- Radionuclides**, *Pinus sylvestris* 8560
- Raphanus sativus***
 air pollution 8588
 breeding 8586
 molecular genetics, leghaemoglobin 8587
 sulfur dioxide 8588
 turnip mosaic potyvirus 8602
 varieties, Sudarushka 8586
- Recombination** 7804
 (see also Mitotic recombination)
Lycopersicon esculentum, computer simulation 8644
Pinus sylvestris, isoenzymes 8560
- Regenerative ability**
Oryza sativa 8151
Rubus idaeus 8501
Solanum tuberosum 8231-8232
Vitis vinifera 8531
- Reports**
 cereals, breeding 8830
 Denmark, Landsudvalget for Planteavl 7848
 seed production 8830
 tissue culture 8830
Vicia faba, breeding 8830
- Reproduction**
Freyinetia, evolution 8549
Pandanus, evolution 8549
Sararanga, evolution 8549
Tremella fuciformis, genetics 8774
- Respiration**
Rubus crataegifolius 8500
Rubus idaeus 8500
Rubus occidentalis 8500
Zea mays 8051
- Restriction fragment length polymorphism**
Rubus
 blackberries 8495
 raspberries 8495
Triticum aestivum, glutenins 7938
- Reviews**
 chromosome aberrations 7824
Fragaria
 ecology 8522
 evolution 8523
 genetics 8522
 polyploidy 8523
Fragaria ananassa
 breeding 8517-8518
 genetics 8521
 genetics, mycorrhizas 7842
 Gramineae, cell culture 7854
Hordeum vulgare, *Erysiphe graminis* 8107
 induced mutations 7824
 ornamental plants
 genetics
 colour 8778
 flavonoids 8778
 flowers 8778
 molecular genetics
 colour 8778
 flavonoids 8778
 flowers 8778
 self incompatibility 7829
 transposable elements 7820
Triticum aestivum
 chromosome pairing 7891
 development 7906
 in vitro culture 7930
 Puccinia graminis 7973
Zea mays, amino acids 8049
Rhizobacter daucus, *Daucus carota* 8585
Rhizobium (see also Bradyrhizobium; Nitrogen fixation)
Rhizoctonia (see also Macrophomina)
Rhizoctonia solani, *Oryza sativa* 8158, 8160
 Rhizomes, *Boehmeria nivea*, height 8297
Rhododendron, cold resistance 8828
Rhopalosiphum padi, *Triticum aestivum*, techniques 7978
- Ribes**
 varieties, Rikö 8509
 black currants
 breeding 8509

Somatic recombination (see Mitotic recombination)**Sorghum bicolor**

- climate 7857
- cold resistance 8126
- Colletotrichum graminicola* 8119
- Contarinia sorghicola* 8119
- gene expression, phosphoenolpyruvate carboxylase 8123
- genetic engineering, phosphoenolpyruvate carboxylase 8123
- interspecific hybridization 8118, 8120
- polyploidy 8124
- Sphacelotheca sorghi* 8128
- stress 7857
- tissue culture 8125
- variety trials 8119
- varieties 8120
 - Early Amber 8126
 - K441V 8126
 - Kansas Orange 8126
 - Zernogradskii Yantar' 8121
 - Zernogradskoe-3 8126
 - Zernogradskoe-53 8128

Sorghum sudanense

- breeding 8118
- ethyl methanesulfonate 8127
- induced mutations, salinity 8127
- interspecific hybridization 8118, 8120
- mutagens 8127
- varieties 8120
 - Mironovskaya-8 8122

Sorosporium (see also *Sphacelotheca*)Sowing date, *Glycine max* 8732**Soybean mosaic potyvirus**, *Glycine max*

8740, 8743

Spacing (see Crop density)**Speciation** (see Evolution)Specific gravity, *Pinus taeda* 8563**Sphacelotheca sorghi**, *Sorghum bicolor*

8128

Sphaerotheca mors-uvae**Ribes**

- black currants
 - genetics 8515
 - modifiers 8515

Sphaerulina (see also *Cercospora*)*Spinacia oleracea*, breeding 8604**Spines**

- Rubus*, raspberries 8497
- Rubus idaeus*, genetics 8497

Spring and winter habit

- Hordeum vulgare*, genetics 8089
- Triticum aestivum* 7907
- genetics 7917

Spear types, *Pyrus communis* 8415**Stability**

- Cucumis sativus*, yield components 8626
- Fragaria ananassa* 8524
- Gossypium*, yields 8289
- Helianthus annuus* 8373
- Hordeum vulgare*, yield components 8098
- Lupinus luteus*, yields 8214
- Zea mays*, yields 8056

Stachydidium (see also *Verticillium*)**Starch**

- Glycine max* 8715
- Triticum aestivum* 7941

Statistics

- crop plants 7806
- forest trees 8539
- genetic markers 7819
- genotype environment interaction 7801
- Hordeum vulgare* 7806
- quantitative genetics 7819
- variety trials 7801

Stemphylium (see also *Alternaria*)**Stems** (see also Internodes)**Sterility**

- Hordeum* × *Triticum* 7873
- Medicago sativa*, techniques 8197
- Secale cereale* 8000
- Secale* × *Triticum*, nucleocytoplasmic interaction 7875

Sterols, *Lycopersicon peruvianum*, in vitro selection 8664**Stomata**, *Oryza sativa* 8140**Stress** 7800

flowering 7808

Stress cont.

Glycine max 8721
Lycopersicon esculentum, techniques 7845

Pisum sativum 8189*Secale* × *Triticum* 7879*Sorghum bicolor* 7857*Triticum aestivum*, techniques 7845*Vicia sativa* 8189*Zea mays* 7857

Striga gesnerioides, *Vigna unguiculata* 8692

Stromatinia gladioli*Gladiolus* 8812*Gladiolus italicus* 8812**Sugars***Beta vulgaris*, sugarbeet 8326*Capsicum annuum* 8676*Eriobotrya japonica* 8422Sulfur dioxide, *Raphanus sativus* 8588*Swartzia*, taxonomy 8552

Synopsis (see Chromosome pairing)

Synchytrium endobioticum, *Solanum tuberosum* 8236

Syndesis (see Chromosome pairing)

Synthetic varieties

triticale 7983

Triticum aestivum, books 7885*Zea mays* 8008

techniques 8011

Tannins, *Eriobotrya japonica* 8422**Taxonomy***Bhidea borii* 8186*Brugmansia*, books 8840*Chusquea* 8577*Conceveiba africana* 8555*Cornus* 8551*Cyrtocarpa* 8553*Glycine max* 8731

grasses, computer programming 8173

Onobrychis arenaria 8209*Onobrychis montana* 8209*Onobrychis viciifolia* 8209*Poa* 8174*Solanum* 8554*Swartzia* 8552*Ticodendron incognitum* 8547-8548*Urginea* 8800**Techniques**

Allium sativum, garlic mosaic virus 8597

Beta vulgaris

sugarbeet

breeding 8311

heterosis 8315

Brassica

rape

diploidy 8348

protoplasts 8355

breeding 7804-7805

cereals

breeding 7847

seed production 7847

tryptophan 7855

variety classification 7923

chromosome aberrations 7824

Corylus

isoenzymes 8537

variety classification 8537

crop plants, *Fusarium* 7809*Cucumis melo*, haploidy 8613

epistasis 7821

fruit crops, self compatibility 8405

genetic variance 7821

Glycine max

breeding 8697

genetic transformation 8700

photoperiodism 8715

proteins 8730

Gossypium, breeding 8247

Gossypium barbadense, germination 8274

grasses, variety classification 8172

*Helianthus annuus**Plasmopara halstedii* 8376*Sclerotinia sclerotiorum* 8374

variety classification 8367, 8369

Hordeum vulgare*Cochliobolus sativus* 8104

cold resistance 8101

Fusarium 8104**Techniques cont.****Hordeum vulgare cont.**

haploidy 8079-8080

induced mutations 7824

Lupinus, alkaloids 8213*Lycopersicon esculentum*

germination 8652

stress 7845

Medicago sativa

embryo sac 8197

Fusarium 7809

protoplasts 8198-8199

sterility 8197

Melilotus alba, salinity 8211*Melilotus dentata*, salinity 8211*Melilotus officinalis*, salinity 8211

molecular genetics 7814

Pinus pinaster, *Melampsora populnea* 8570

Pisum sativum, foliage area 8754

quantitative genetics 7821

Saccharum officinarum, *Glomerella tucumanensis* 8304

Salvia sclarea, hybrid seed production 8773

Secale cereale

breeding 8003

Erysiphe graminis 8007

foliage area 8002

leaves 8002

self incompatibility 7830

Solanum dulcamara

protoplasts 8399

tissue culture 8399

tissue culture 7831

Trifolium pratense, *Fusarium* 7809*Triticum aestivum*

drought resistance 7952

Fusarium 7809

quality 7939, 7943

Rhopalosiphum padi 7978

stress 7845

variety classification 7923

Zea mays

breeding 8008, 8011

digestibility 8052

lodging 8037

pollination 8011

synthetic varieties 8011

Temperature*Lilium maculatum* 8809*Panicum miliaceum* 8111*Solanum tuberosum* 8241Terpenoids, *Melissa officinalis* 8388*Theobroma cacao*, yields 8344**Thuja occidentalis**

gene flow 8575

genetics, isoenzymes 8575

heterozygosity, isoenzymes 8575

Ticodendron incognitum

inflorescences 8547

pollen 8548

sex 8547

taxonomy 8547-8548

Tissue culture 7833*Actinidia deliciosa* 8478

Aegilops × *Triticum*, nucleocytoplasmic interaction 7933

Agropyron × *Triticum*, nucleocytoplasmic interaction 7933*Artemisia dracuncululus* 8398*Asparagus cooperi* 8814

Beta vulgaris, sugarbeet 8317, 8323-8324

Cocos nucifera 8475*Coffea arabica* 8342*Coleus forskohlii* 8397*Colocasia esculenta* 8244

crop plants 7832

Cucumis sativus 8629, 8632*Cupressocyparis leylandii* 8576*Dalbergia sissoo* 8550*Ficus benjamina* 8813*Glycine gracilis* 8720*Glycine max* 8723*Gossypium barbadense* 8282-8283*Gossypium hirsutum* 8282-8283*Helianthus annuus* 8372*Hordeum* × *Secale* 8073*Hordeum* × *Triticum* 8073*Ipomoea batatas* 8243

Tissue culture *cont.*

- Lachenalia* 8805
- Lycium barbarum* 8393
- Mangifera indica* 8469
- Nicotiana tabacum* 8336-8337
- Onobrychis vicifolia* 8210
- Oryza sativa* 8149, 8151
- Pisum sativum* 8678, 8761-8762
- Prunus persica* 8441
- Pyrus communis* 8419-8420
- reports 8830
- Ribes nigrum* 8514
- Rubus idaeus* 8501
- Saccharum* 8301
- Secale cereale* 8004
- Secale* × *Triticum* 7890
- Solanum berthaultii* 8229
- Solanum dulcamara*, techniques 8399
- Solanum tuberosum* 8229, 8232
- Sorghum bicolor* 8125
- techniques 7831
- Trifolium repens* 8205
- Triticum aestivum* 7894, 7932, 7934
- nucleocytoplasmic interaction 7933
- Vicia faba* 8678, 8680
- Vitis vinifera* 8531-8532
- Zea mays* 8044

Tobacco mosaic tobamovirus, *Lycopersicon esculentum* 8661**Toxic soils** (see Soil toxicity)**Toxic substances**

- Glycine max* 8736-8737
- Hordeum vulgare* 8102
- Oryza sativa* 8156

Tradescantia ohiensis, chromosome disposition 8785**Transgression**, *Oryza sativa*, yield components 8135**Translocation**

- Aegilops* 7925
- Pinus taeda* 8564
- Triticum* 7925

Translocation, cytological (see Chromosome translocation)**Transpiration**, *Cajanus cajan* 8770**Transposable elements**

- Gossypium* 7820
- reviews 7820
- Triticum aestivum* 7884
- Zea mays* 8022

Tremella fuciformis, genetics, reproduction 8774**Trichoconis** (see *Alternaria*)**Trichomes** (see Plant hairs)**Trifolium ambiguum**

- crop mixtures 8208
- yield components 8208

Trifolium pratense

- artificial selection, yields 8203
- foliage area 8203
- photosynthesis 8203
- techniques, *Fusarium* 7809

Trifolium repens

- aluminium 8206
- Ditylenchus dipsaci* 8204
- genetic resources 8204
- morphology 8204
- soil toxicity 8206
- tissue culture 8205
- varieties, Grasslands Huia 8206

Trifolium subterraneum, varieties, Nuba 8207**Tripsacum** × *Zea*

- apomixis 8034
- intergeneric hybridization 8034

Triticale

- amino acids 7993
- breeding 7984, 7989
- chromosome pairing 7988
- chromosome substitution 7988
- fertility 7991
- genetic variance, proteins 7992
- genetics, pairing 7987
- genomes 7989
- height 7991
- inbreeding 7983
- lysine 7993
- mutagens 7991
- mutations, pairing 7987
- proteins 7993
- synthetic varieties 7983

Triticale *cont.*

- variety trials 7985
- yield components 7983, 7991
- varieties
 - ad3/5 7985
 - Bashkirskii-1 7984
 - D160 7985
 - D161 7985
 - D178 7985
 - Dar Belorussii 7986
 - Don santiago INTA 7849

Triticale × *Secale*, intergeneric hybridization 7990**Triticum** (see also *Aegilops*)

- chromosome pairing 7878, 7886
- embryo sac 7876
- evolution 7925
- genomes 7925
- interspecific hybridization 7933
- nitrogen 7925
- nutrients 7925
- Puccinia graminis* 7886
- Puccinia recondita* 7982
- selective fertilization 7878
- translocation 7925

Triticum aestivum

- acid phosphatase 7971
- amino acids 7937
- anatomy 7905
- aneuploidy 7893
- anther culture 7929, 7932
- arabitol 7972
- artificial selection
 - germination 7911
 - photoperiodism 7914
 - vernalization 7914
 - weathering 7977
 - yield components 7918
 - yields 7946
- aspartate aminotransferase 7971
- awns 7910, 7954
- backcrossing 7868
- barley yellow dwarf luteovirus 7976
- benzyladenine 7866
- breeding 7835
- cell culture 7932
- chlormequat 7827
- chloroplast genetics, ribulose-bisphosphate carboxylase 7865
- chloroplasts 7892
- chromosome aberrations 7827, 7883, 7894
- chromosome pairing 7893, 7970
- reviews 7891
- chromosome substitution 7893
- proteins 7890
- chromosome translocation 7867
- yield components 7902
- cold resistance 7953, 7956
- combining ability
 - leaves 7904
 - yield components 7904
- competition 7951
- computer programming 7859
- cytokinins 7827, 7866
- cytoplasm 7851
- cytoplasmic inheritance 7851
- cytoplasmic male sterility 7892
- databases 7859
- development, reviews 7906
- DNA 7953
- drought resistance 7954-7955
- Erysiphe graminis* 7959, 7961-7962
- esterases 7971
- ethephon 7827
- ethylene releasers 7827
- ethyleneimine 7882
- N*-ethyl-*N*-nitrosourea 7883
- evolution 7850, 7917
- Fusarium* 7963
- gamma radiation 7881
- gene expression, ribulose-bisphosphate carboxylase 7865-7866
- gene location
 - α -amylase 7912-7913
 - awns 7909
 - enzymes 7850
 - Erysiphe graminis* 7850
 - gliadin 7944
 - height 7908-7909
 - inflorescences 7909

Triticum aestivum *cont.*

- gene location *cont.*
 - internodes 7908
 - isoenzymes 7913
 - photoperiodism 7908
 - proteins 7945
- Puccinia graminis* 7850
- Puccinia recondita* 7850, 7966
- seeds 7945
- yield components 7928
- genetic markers 7868, 7870
- gliadin 7931
- glutenins 7931
- genetics 7975
 - α -amylase 7912-7913
 - awns 7917
 - chromosome pairing 7891
 - enzymes 7850
 - Erysiphe graminis* 7850, 7964
 - glutenins 7938
 - height 7919, 7921
 - inflorescences 7883, 7917
 - isoenzymes 7913
 - Mayetiola destructor* 7979
 - plant hairs 7869
 - Puccinia graminis* 7850
 - Puccinia recondita* 7850, 7967, 7970-7971, 7974
 - Puccinia striiformis* 7965
 - spring and winter habit 7917
 - waxes 7869
 - yields 7919
- genomes 7850
- genotype mixtures 7951
 - Erysiphe graminis* 7960
 - Puccinia recondita* 7960
- germplasm releases
 - Mayetiola destructor* 7957
 - Puccinia recondita* 7966
 - Schizaphis graminum* 7957
 - soil-borne wheat mosaic furovirus 7957
- Gibberella zeae* 7959
- gibberellic acid 7924
- gliadin 7916, 7942
- growth regulators 7827, 7866, 7924
- heat resistance 7955
- height 7924, 7950, 7991
- heritability
 - height 7927
 - yield components 7918, 7927
- heterosis
 - Erysiphe graminis* 7960
 - Puccinia recondita* 7960
- in vitro* culture, reviews 7930
- induced mutations 7881-7882, 7884, 7991
 - height 7916
 - inflorescences 7883
- interspecific hybridization 7876, 7886, 7892, 7922, 7937, 7962, 7968, 7970
- isoenzymes 7971
- leaves 7901
- Leptosphaeria avenaria* 7958
- Leptosphaeria nodorum* 7958
- linkage, α -amylase 7912
- lodging 7905, 7908
- manganese 7947
- mannitol 7972
- meiosis 7893-7894
- N*-methyl-*N*-nitrosourea 7883, 7916
- mitochondria 7892
- molecular genetics, secalin 7867
- mutagens 7827, 7881-7883, 7916, 7991
- mutations, books 7885
- Mycosphaerella graminicola* 7958
- mycotoxins 7963
- nitrate reductase 7955
- nitrogen fixation 7949-7950
- nitrogenase 7950
- nucleocytoplasmic interaction
 - aneuploidy 7895
 - chromosome pairing 7895
 - meiosis 7853
 - Puccinia recondita* 7968
 - tissue culture 7933
 - yields 7922
- nucleolus organizer 7852
- nutrients 7947
- photoperiodism 7907

***Triticum aestivum* cont.**

- pleiotropy
 - nitrogen 7921
 - nutrients 7921
 - yield components 7928
 - yields 7921
 - polymorphism, glutenins 7915
 - proteins 7903, 7937
 - Pseudomonas syringae* 7958
 - Puccinia graminis* 7959, 7972
 - reviews 7973
 - Puccinia recondita* 7959, 7961-7962, 7969
 - Puccinia striiformis* 7959
 - quality 7935-7936, 7941-7942
 - restriction fragment length polymorphism, glutenins 7938
 - RNA 7953
 - seedlings 7903
 - selective fertilization 7913
 - soil pH 7946
 - somaclonal variation
 - gliadin 7931
 - glutenins 7931
 - plant hairs 7926
 - spring and winter habit 7907
 - starch 7941
 - synthetic varieties, books 7885
 - techniques
 - drought resistance 7952
 - Fusarium* 7809
 - quality 7939, 7943
 - Rhopalosiphum padi* 7978
 - stress 7845
 - variety classification 7923
 - tissue culture 7894, 7932, 7934
 - transposable elements 7884
 - ultrastructure 7892
 - variety classification 7915
 - variety trials 7860
 - vernalization 7907
 - yield correlations 7927, 7936
 - varieties 7943, 7958
 - Albidum-114 7953
 - Don-85 7862
 - Ferrugineum-1109 7904
 - Ganchun-16 7838
 - Kenya Civet 7964
 - Mironovskaya-40 7864
 - Mironovskaya-808 7904
 - Obelisk 7861
 - Odesskaya-66 7904
 - Promin' 7904
 - Tian-867 7959
 - TP114/65A 7964
 - Yunnat Odesskii 7863
- Triticum dicoccoides***
- chlorotoluron 7980
 - difenoquat 7980
 - herbicides 7980
 - interspecific hybridization 7892
 - metoxuron 7980
 - proteins 7903
 - seedlings 7903
- Triticum dicoccum*, interspecific hybridization 7922**
- Triticum durum***
- amino acids 7937
 - artificial selection, quality 7940
 - chromosome aberrations 7883
 - chromosome addition 7887
 - chromosome substitution 7887
 - computer programming 7859
 - databases 7859
 - drought resistance 7955
 - N*-ethyl-*N*-nitrosourea 7883
 - genetics
 - height 7920
 - inflorescences 7883
 - yield components 7920
 - heat resistance 7955
 - induced mutations, inflorescences 7883
 - interspecific hybridization 7886-7887, 7937
 - irrigation 7948
 - N*-methyl-*N*-nitrosourea 7883
 - mutagens 7883
 - nitrate reductase 7955
 - nucleolus organizer 7852
 - proteins 7903, 7937
 - seedlings 7903

- Triticum militinae*, interspecific hybridization 7970
- Triticum timopheevii*
 - genetics, *Puccinia recondita* 7970
 - interspecific hybridization 7876, 7878, 7962, 7970
- Triticum* × *Aegilops*, intergeneric hybridization 7874, 7877, 7892, 7898-7899, 7933, 7957, 7966, 7968
- Triticum* × *Agropyron*, intergeneric hybridization 7871, 7933
- Triticum* × *Elymus*, intergeneric hybridization 7897, 7900
- Triticum* × *Hordeum*, intergeneric hybridization 7853, 7872-7873, 8073, 8078
- Triticum* × *Secale* (see also *Triticale*)
 - intergeneric hybridization 7853, 7867, 7875-7876, 7879-7880, 7888-7889, 7893, 7895-7896, 7900, 7991
- Trypsin inhibitors**
 - Glycine max* 8725
 - linkage 8701
- Tryptophan, cereals, techniques 7855**
- Tubers**
 - Solanum berthaultii* 8229
 - Solanum tuberosum* 8229
- Tulipa*, combining ability, *Fusarium oxysporum* 8811
- Tulipa gesneriana*
 - combining ability, *Fusarium oxysporum* 8811
 - varieties
 - Aristocrat 8811
 - Black Parrot 8811
 - Lucky Strike 8811
- Turnip mosaic potyvirus**
 - Brassica*
 - cabbages 8602
 - Chinese cabbages 8602
 - Raphanus sativus* 8602
- Twinning, *Oryza sativa* 8139**
- Ultrastructure**
 - Aegilops* × *Triticum* 7892
 - Triticum aestivum* 7892
- Ultraviolet radiation, *Nicotiana tabacum* 8337**
- Unreduced gametes**
 - Beta vulgaris*
 - sugarbeet
 - genetics 8316
 - mutations 8316
 - Elymus* × *Triticum* 7900
 - Secale* × *Triticum* 7888, 7900
 - Solanum tuberosum* 8220
- Urginea***
 - chromosome morphology 8800
 - chromosome number 8800
 - taxonomy 8800
- Uromyces appendiculatus*, *Vigna unguiculata* 8690**
- Ustilaginoides virens*, *Oryza sativa* 8158**
- Varities (significant varieties are located at the end of the entries for each crop)**
- Varities (see also Germplasm releases; Hybrid varieties; Synthetic varieties)**
- Variety classification**
 - cereals, techniques 7923
 - Corylus*, techniques 8537
 - Dactylis glomerata* 8175
 - grasses, techniques 8172
 - Helianthus annuus*, techniques 8367, 8369
 - Hordeum vulgare* 8084
 - Rubus*, raspberries 8499
 - Solanum tuberosum* 8227
 - Triticum aestivum* 7915
 - techniques 7923
 - Zea mays* 8021
- Variety trials**
 - Arachis hypogaea* 8379
 - Beta vulgaris*, sugarbeet 8313
 - Brassica*, rape 8347
 - cereals 7846, 7848
 - Cucumis sativus* 8623-8624
 - Dahlia pinnata* 8796
 - Dianthus caryophyllus* 8780
 - Gossypium* 8253
 - Helianthus annuus* 8364
 - Hippeastrum* 8797
 - Hordeum vulgare* 8065-8066

Variety trials cont.

- Leucaena leucocephala* 8215
- Malus pumila* 8406
- Medicago sativa* 8193
- Papaver somniferum* 8391
- Prunus persica* 8431-8432
- Ribes nigrum* 8513
- Rubus idaeus* 8494
- Secale cereale* 7985
- Solanum tuberosum* 8222
- Sorghum bicolor* 8119
- statistics 7801
- triticales 7985
- Triticum aestivum* 7860
- Vitis vinifera* 8527
- Vascular system**
 - Cornus* 8551
 - Oryza sativa* 8142
- Vegetables**
 - chromosome number 7817
 - fungi 8580
 - genetic resources 7837
 - Phoma* 8635
 - varieties 8579
- Vegetative propagation**
 - Allium sativum* 8594
 - Liquidambar styraciflua* 8825
- Veitchia merrillii***
 - cryopreservation 7843
 - genetic resources 7843
- Venturia inaequalis*, *Pyrus communis* 8415**
- Verbena hastata*, pollination 8789**
- Verbena stricta*, pollination 8789**
- Verbena urticifolia*, pollination 8789**
- Vernalization**
 - Triticum aestivum* 7907
 - artificial selection 7914
- Verticillium albo-atrum*, *Rubus*, raspberries 8504**
- Verticillium dahliae*, *Gossypium hirsutum* 8292-8293**
- Vicia***
 - cold resistance 8188
 - drought resistance 8188
 - genetic resources 8188
- Vicia faba***
 - aneuploidy 8678
 - breeding, reports 8830
 - gamma radiation 8679
 - in vitro* selection
 - chlorophyll 8678
 - herbicides 8678
 - propazine 8678
 - propham 8678
 - induced mutations 8679
 - polyploidy 8680
 - tissue culture 8678, 8680
 - varieties, Lincan-2 7838
- Vicia sativa***
 - breeding 8189
 - induced mutations 8187
 - stress 8189
- Vicilin**
 - evolution 7815
 - molecular genetics 7815
- Vigna mungo***
 - interspecific hybridization 8693
 - polyploidy 8693
- Vigna radiata***
 - cryopreservation 7843
 - gamma radiation 8694
 - genetic resources 7843
 - induced mutations, mung bean yellow mosaic geminivirus. 8694
 - interspecific hybridization 8693
 - polyploidy 8693
- Vigna unguiculata***
 - cowpea (aphid-borne) mosaic potyvirus 8691
 - cucumber mosaic cucumovirus 8691
 - Striga gesnerioides* 8692
 - Uromyces appendiculatus* 8690
 - varieties
 - Santee Early Pinkeye 8689
 - B301 8692
- Viruses 7810**
- Vitis***
 - morphology 8530
 - varieties
 - Bhatta Ribba Black 8530
 - Skibba White 8530

Vitis vinifera

- growth period 8526, 8529
- heat resistance 8533
- quality 8526
- regenerative ability 8531
- solar radiation 8533
- tissue culture 8531-8532
- variety trials 8527
- varieties

- books 8841
- 8526, 8529
- 21B 8527
- Salba n 8528

Waterlogging, Prunus, plums 8423**Watermelon mosaic potyvirus**

- Cucumis sativus* 8612
- Cucurbita* 8612

Waxes

- Triticum aestivum*, genetics 7869
- Zea diploperennis* 8036
- Zea mays* 8036
- Zea mexicana* 8036

Weathering, Triticum aestivum, artificial

- selection 7977

Whetzelinia (see Sclerotinia)**Wide hybridization**

- fodder legumes 8169
- grasses 8169
- Oryza sativa* 8130, 8135
- Solanum tuberosum* 8220

Wilts

- Gossypium* 8249
- Gossypium hirsutum* 8291

Wind, Pisum sativum 8752**Xanthomonas campestris**

- Brassica*, cabbages 8600-8601
- Gossypium* 8290
- Lycopersicon esculentum* 8658
- Oryza sativa* 8158
- genetics 8130, 8159
- linkage 8130
- Prunus persica*, *in vitro* selection 8450

Xanthomonas populi, Populus trichocarpa 8541**Yield components**

- Allium sativum*
 - genetic variance 8595
 - heritability 8595
- Arachis hypogaea* 8383
- Avena sativa*
 - genetic variance 7995
 - heritability 7995
- Capsicum annuum*, heritability 8673
- Cicer arietinum* 8766
- Cucumis sativus*
 - genotype environment interaction 8626
 - stability 8626
- Glycine*, genetic variance 8704
- Glycine max* 8702, 8713
- Glycine soja* 8702
- Gossypium* 8249
- Gossypium hirsutum* 8275
- Hordeum vulgare* 8100
- pleiotropy 8086
- stability 8098
- Lilium* 8804
- Lupinus luteus* 8212
- Oryza sativa* 8155
 - combining ability 8146
 - heterosis 8146
 - transgression 8135
- Phaseolus vulgaris*, artificial selection 8681
- Pinus monticola*, heritability 8565
- Pisum sativum* 8760
 - pleiotropy 8755
- Ribes nigrum* 8512
- Secale cereale* 8006
- Secale* × *Triticum* 7991
- Solanum melongena*, heterosis 8666
- Solanum tuberosum*, combining ability 8221
- Trifolium ambiguum* 8208
- triticales 7983, 7991
- Triticum aestivum*
 - artificial selection 7918
 - chromosome translocation 7902
 - combining ability 7904
 - gene location 7928
 - heritability 7918, 7927

Yield components cont.

- Triticum aestivum* cont.
 - pleiotropy 7928
- Triticum durum*, genetics 7920
- Zea mays*, heritability 8027

Yield correlations

- Avena sativa* 7994
- Brassica*, rape 8352-8353
- Capsicum annuum* 8673
- Citrullus lanatus* 8615
- Gossypium hirsutum* 8281
- Oryza sativa* 8143, 8145
- Pisum sativum* 8758
- Saccharum officinarum* 8303
- Triticum aestivum* 7927, 7936

Yields

- Glycine max*, induced mutations 8729
- Gossypium*
 - combining ability 8289
 - heterosis 8258
 - stability 8289
- Gossypium hirsutum*, artificial selection 8281
- Lupinus luteus*, stability 8214
- Solanum tuberosum*, artificial selection 8221
- Theobroma cacao* 8344
- Trifolium pratense*, artificial selection 8203
- Triticum aestivum*
 - artificial selection 7946
 - genetics 7919
 - nucleocytoplasmic interaction 7922
 - pleiotropy 7921
- Zea mays*
 - combining ability 8024, 8040
 - genotype environment interaction 8024
 - heterosis 8040
 - stability 8056

Zea diploperennis, waxes 8036**Zea mays**

- accessory chromosomes 8028
- amino acids 8046, 8054
- reviews 8049
- anther culture 8043
- apomixis 8034
- artificial selection 8008
- Fusarium* 8058
- Helicoverpa zea* 8062
- inflorescences 8062
- Aspergillus flavus* 8060
- 1,4-bisdiazaoacetylbutane 8025, 8027
- breeding 8010, 8012-8014
- chromosome morphology 8028-8030
- climate 7857
- combining ability
 - moisture content 8039
 - yields 8024, 8040
- controlling elements 8021
- Diatraea grandiosella* 8061
- digestibility 8054
- embryo culture 8042
- endosperm 8047, 8049
- ethyl methanesulfonate 8018
- fatty acids 8046
- flowering 8029
- gamma radiation 8019, 8025, 8041
- gene expression
 - cold 7856
 - zein 8018
- gene location, habit 7841
- genetic markers 8021
- genetic resources 8015
- genetic transformation 8019
- genetic variance
 - lysine 8048
 - proteins 8048
- genetics
 - crossing over 8032
 - β -glucosidase 8023
 - habit 7841, 8032
 - meiosis 8033
 - proteinases 8055
 - zein 8055
- genotype environment interaction, yields 8024
- germplasm releases
 - lodging 8038
 - seed moisture 8038
- glutamate dehydrogenase 8044

Zea mays cont.

- growth period 8010, 8013-8014, 8016
- haploidy 8031
- herbicides 8046
- heritability
 - height 8027
 - yield components 8027
- heterochromatin 8028-8030
- heterosis 8020, 8026
- yields 8040
- hybrid varieties 8012, 8014, 8016-8017
- in vitro* selection
 - amino acids 8050
 - lysine 8050
- inbreeding 8009
- induced mutations 8027
 - chlorophyll 8041
 - habit 7841
 - zein 8018
- lysine 8046, 8049, 8051, 8053
- Macrophomina phaseolina* 8059
- molecular genetics 8020-8021
 - heat shock 8057
 - zein 8018
- mutagens 8018, 8025, 8027, 8041
- mutations 8026
 - crossing over 8032
 - habit 8032
 - meiosis 8033
 - proteinases 8055
 - zein 8055
- nitrogen 8051
- nitroso compounds 8027
- nutrients 8051
- oils 8046
- pleiotropy, cytoplasmic male sterility 8035
- pollen 8019
- polysaccharides 8060
- prometryn 8046
- proteins 8053-8054
- respiration 8051
- silage 8052
- silver nitrate 8042
- somaclonal variation 8045
- stability, yields 8056
- stress 7857
- synthetic varieties 8008
- techniques
 - breeding 8008, 8011
 - digestibility 8052
 - lodging 8037
 - pollination 8011
 - synthetic varieties 8011
- tissue culture 8044
- transposable elements 8022
- variety classification 8021
- waxes 8036
- varieties 8015-8017
 - Bukovinskii-12TV 8012
 - Bukovinskii-14ATV 8012
 - Bukovinskii-18TV 8012
 - Moldavskii-291 8056
 - Moldavskii-391MV 8056
 - Moldavskii-425MV 8056
 - NZ1A 8039

Zea mexicana, waxes 8036**Zea × Tripsacum, intergeneric hybridization 8034****Zein****Zea mays**

- gene expression 8018
- genetics 8055
- induced mutations 8018
- molecular genetics 8018
- mutations 8055

Zinnia elegans, varieties, Sombrero 8783

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